

# NATIONAL 5 PHYSICS

## Unit 1

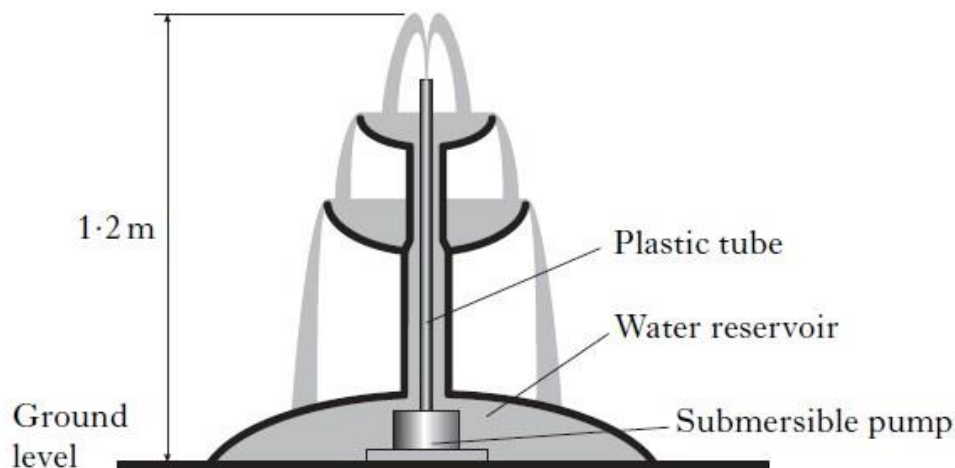
### Electricity and Properties of matter

## Exam Questions

## Conservation of Energy

**2011 C 12**

1. A small submersible pump is used in a garden water fountain. The pump raises 25 kg of water each minute from a reservoir at ground level. The water travels through a plastic tube and reaches a height of 1.2m above ground level.



Calculate how much gravitational potential energy the water gains each minute.

3

**2012 Int2 7 MC**

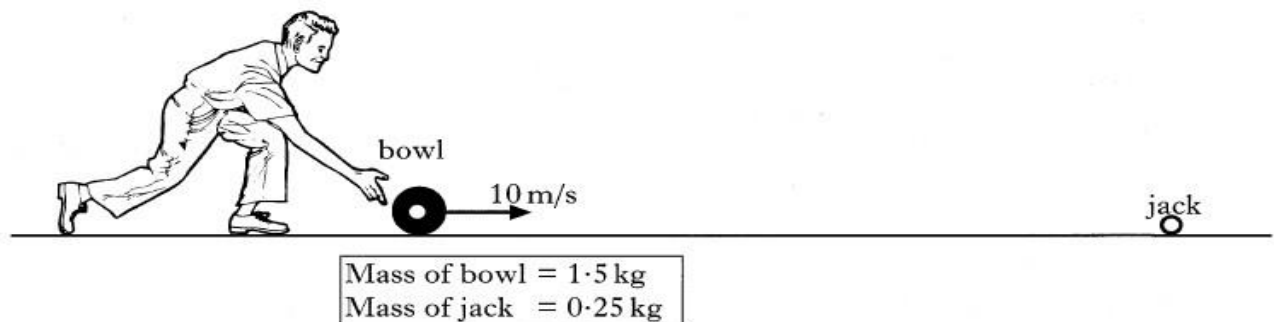
2. An electrical motor raises a crate of mass 500 kg through a height of 12 m in 4 s. The minimum power rating of the motor is

- A 1.25 kW
- B 1.5 kW
- C 15kW
- D 60 kW
- E 240 kW

1

**2005 Int2 21a**

3. In a game of bowls, a bowler releases a bowl with a velocity of  $10 \text{ ms}^{-1}$ .

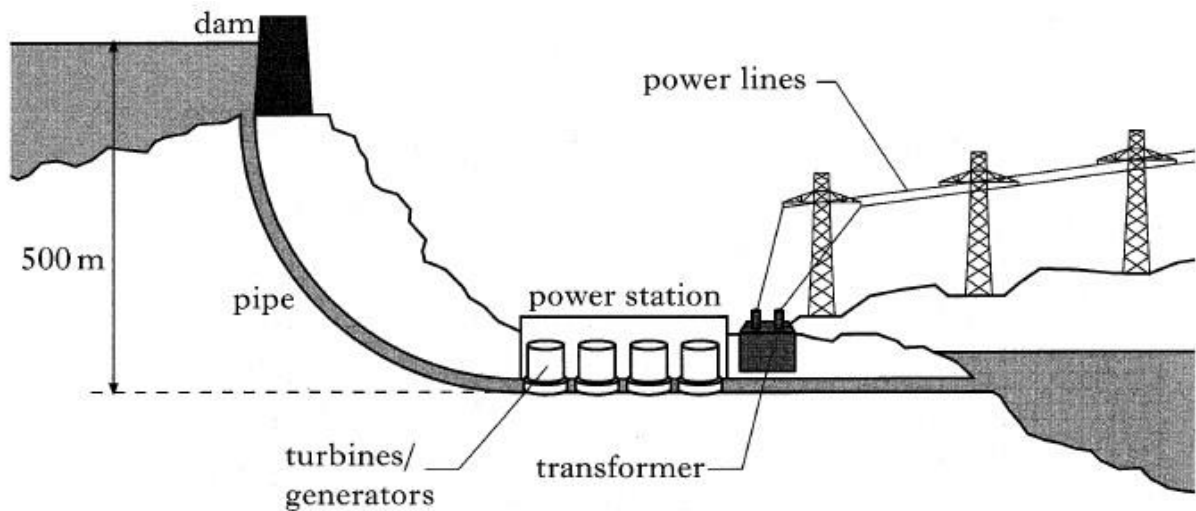


Show that the kinetic energy of the bowl when it is released is 75J.

3

**2005 Int2 23a**

4. A new hydro-electric power station is being planned for the Highlands.



Water is stored in a reservoir at a vertical height of 500m above the power station.

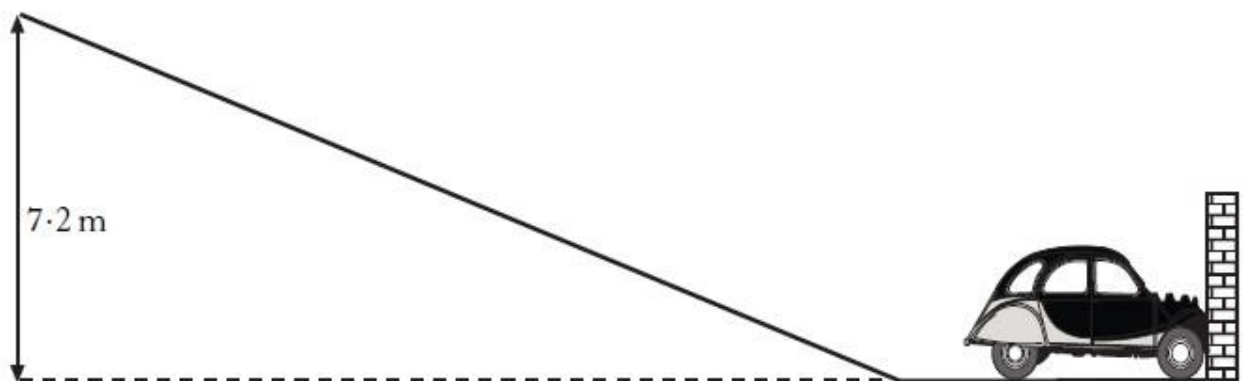
Each second 8000kg of water flows through the power station.

Show that the water loses 40MJ of gravitational potential energy each second.

3

**2008 Int2 24**

5. 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 7.2m high slope.



- (a) Calculate the gravitational potential energy of the car at the top of the slope.

3

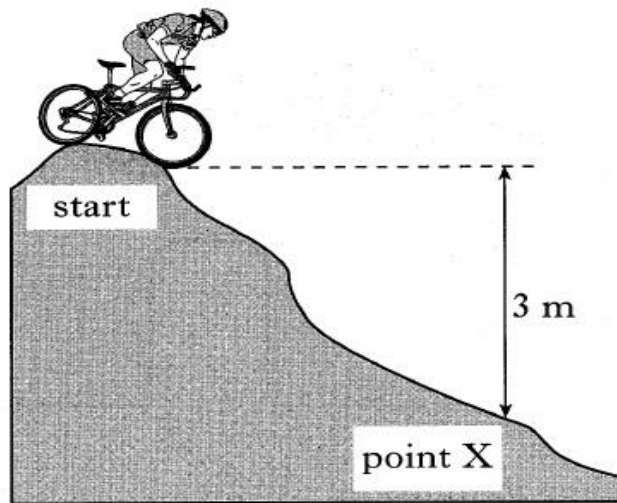
- (b) (i) State the value of the kinetic energy of the car at the bottom of the slope, assuming no energy losses.

1

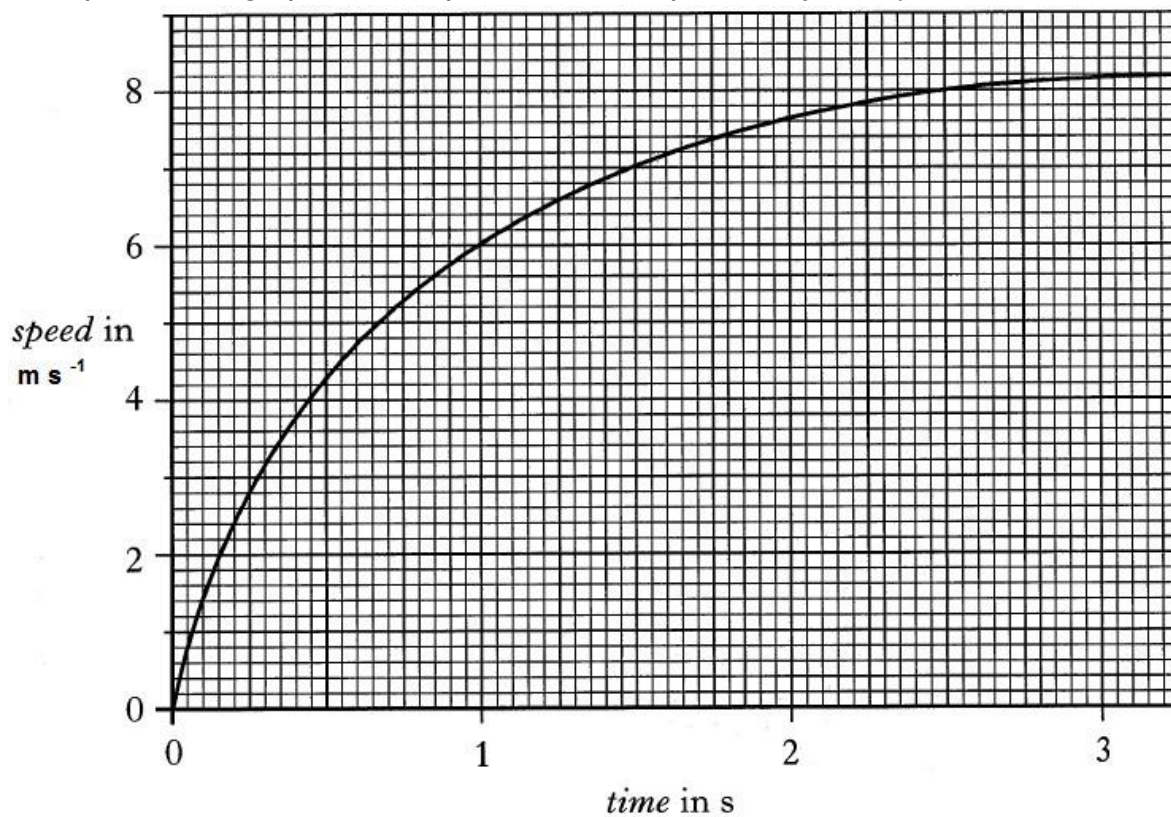
- (ii) Calculate the speed of the car at the bottom of the slope, before hitting the wall.

3

6. In a mountain bike competition, a competitor starts from rest at the top of a hill. He pedals downhill and after 2.5 s he passes point X which is 3 m lower than the start. The total mass of the bike and the competitor is 90 kg.



A speed-time graph for this part of the competitor's journey is shown below.



- (c) Calculate the decrease in gravitational potential energy of the competitor and bike between the start and point X. 3
- (d) Calculate the kinetic energy of the competitor and bike at point X. 3
- (e) Explain the difference between your answers to (a) and (b). 2

## Electric Charge Carriers and Electric Fields

**2011 Int2 26a**

1. A student has two electrical power supplies. One is an a.c. supply and the other is a d.c. supply.  
Explain a.c and d.c. in terms of electron flow in a circuit. 2

**2011 Int2 8 MC**

2. A student makes the following statements about electrical supplies.
- I The frequency of the mains supply is 50 Hz.
  - II The quoted value of an alternating voltage is less than its peak value.
  - III A d.c supply and an a.c. supply of the same quoted value will supply the same power to a given resistor.

Which of the following statements is/are correct?

- A I only
- B II only
- C III only
- D I and II only
- E I, II and III

1

**2012 Int2 14 MC**

3. The current in an  $8\ \Omega$  resistor is 2 A.  
The charge passing through the resistor in 10 s is

- A 4 C
- B 5 C
- C 16 C
- D 20 C
- E 80C

1

**2012 Int2 15 MC**

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

- I In an a.c. circuit the direction of the current changes regularly.
- II In a d.c. circuit positive charges flow in one direction only.
- III In an a.c. circuit the size of the current varies with time.

- A I only
- B II only
- C I and II only
- D I and III only
- E I, II and III

1

**2010 Int2 22(c)**

5. Inside a storm cloud water droplets move around and collide with each other. The motion of water droplets in the cloud causes flashes of lightning. One lightning flash transfers 1650C of charge in 0.15 s.  
Calculate the electric current produced by this flash. 3

**2005 Int2 7MC**

6. An ampere is one  
A volt per joule  
B joule per second  
C joule per coulomb  
D coulomb per second  
E ohm per volt 1

**2005 Int2 9MC**

7. The charge passing a point in a conductor when a current of 4mA flows for 1000s is  
A 0.25C  
B 0.4C  
C 4C  
D 250C  
E 4000C 1

**2006 Int2 26a**

8. Explain the difference between direct current (dc) and alternating current (ac) in terms of the movement of charges in a conductor. 2

## Potential Difference (Voltage)

**2006 Int2 7MC**

1. 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

1

**2007 Int2 7MC**

2. 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.

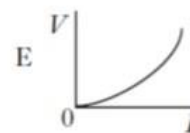
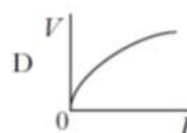
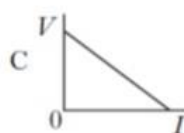
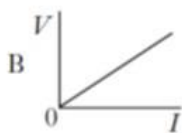
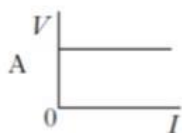
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## Ohm's Law

2011 Int2 6 MC

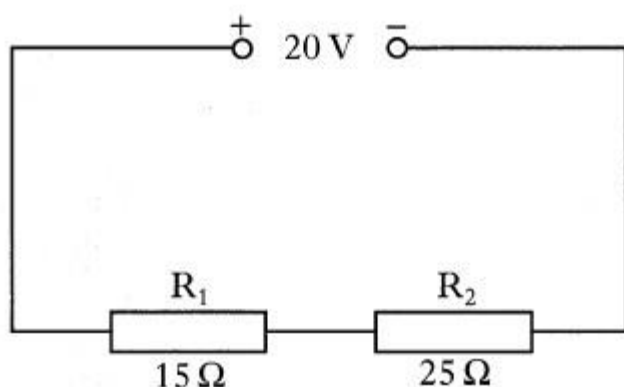
1. Which graph shows how the potential difference  $V$  across a resistor varies with the current  $I$  in the resistor?

1



2005 Int2 25a

2. A student connects two resistors in series with a power supply set at 20V.



- (a) Calculate the current in the circuit.  
(b) Calculate the potential difference across resistor  $R_1$ .  
(c) Redraw the above circuit diagram showing meters correctly connected to measure the quantities in (a) and (b) above.

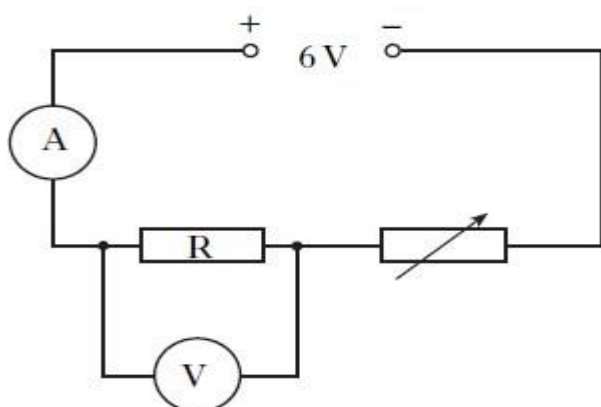
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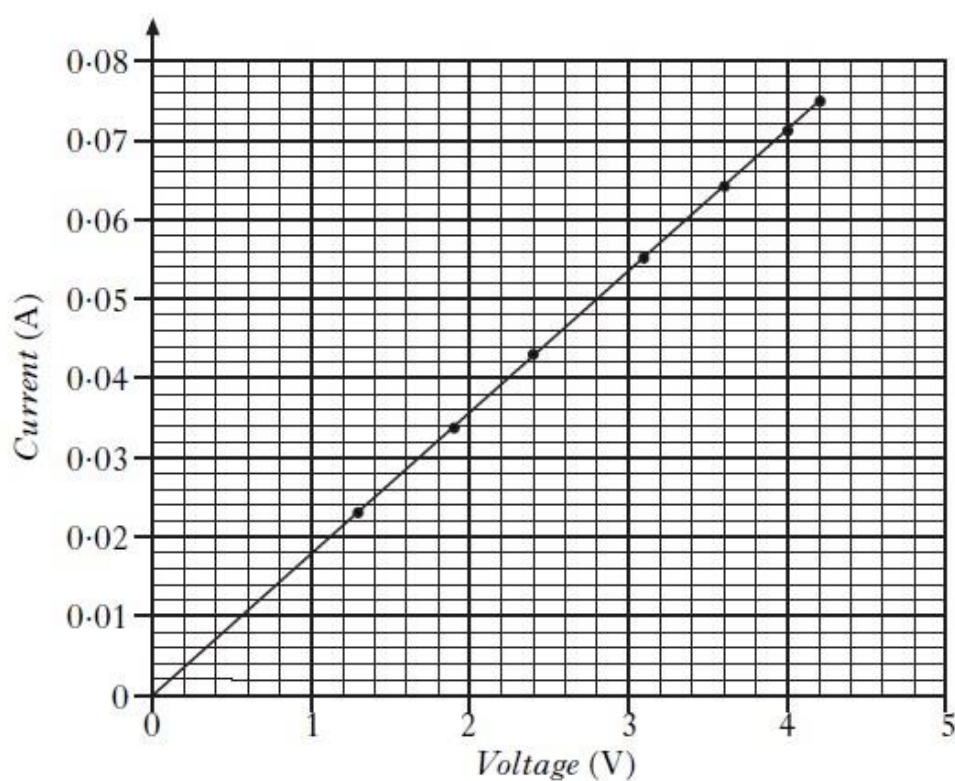
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3. A student sets up the following circuit to investigate the resistance of resistor R.

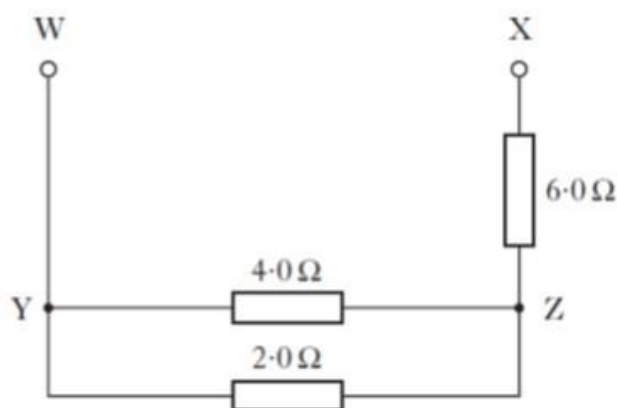


The variable resistor is adjusted and the voltmeter and ammeter readings are noted. The following graph is obtained from the experimental results.



- (a) Calculate the value of the resistor R when the reading on the voltmeter is 4.2V. 4
- (b) Using information from the graph, state whether the resistance of the resistor R, increases, stays the same or decreases as the voltage increases. Justify your answer. 2

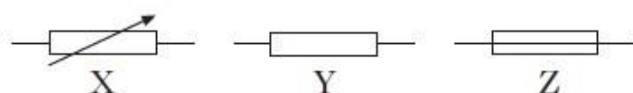
1. Part of a circuit is shown below.



- (a) Calculate the total resistance between points Y and Z. 3
- (b) Calculate the total resistance between points W and X. 3
- (c) Calculate the voltage across the  $2.0\ \Omega$  resistor when the current in the  $4.0\ \Omega$  resistor is  $0.10\ \text{A}$ . 3

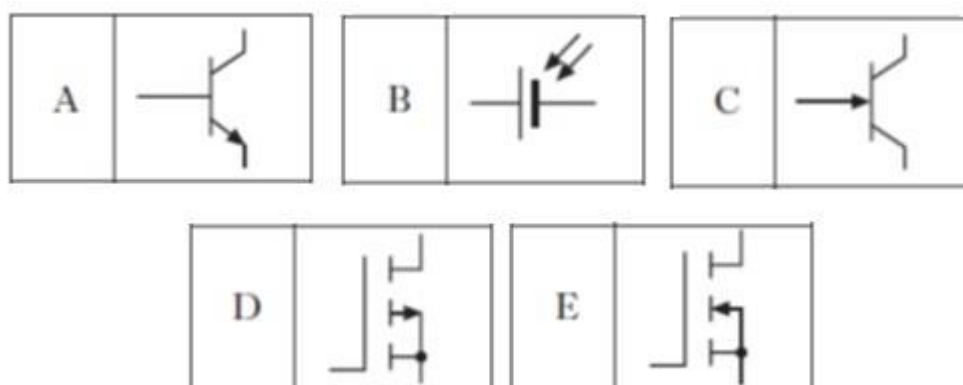
**2011 Int2 5 MC**

2. Which row in the table identifies the following circuit symbols?



	<i>Symbol X</i>	<i>Symbol Y</i>	<i>Symbol Z</i>
A	fuse	resistor	variable resistor
B	fuse	variable resistor	resistor
C	resistor	variable resistor	fuse
D	variable resistor	fuse	resistor
E	variable resistor	resistor	fuse

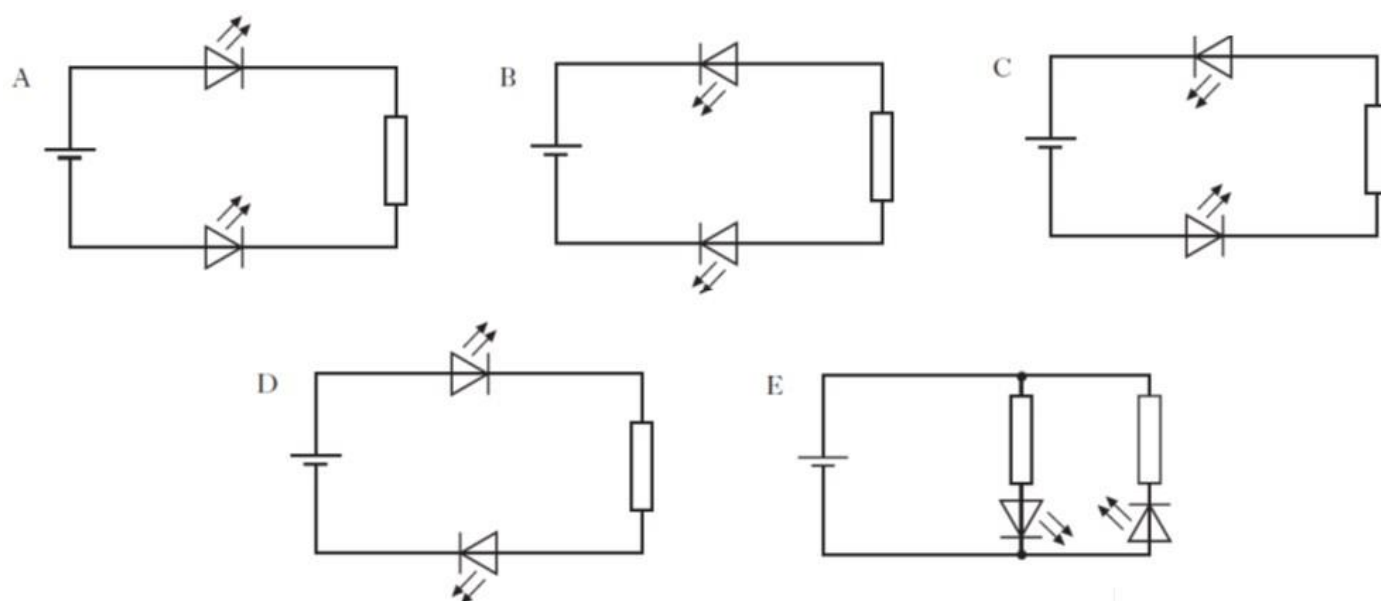
3. Which of the following is the circuit symbol for an NPN transistor?



1

4. A student sets up the circuits shown.  
In which circuit will both LEDs be lit?

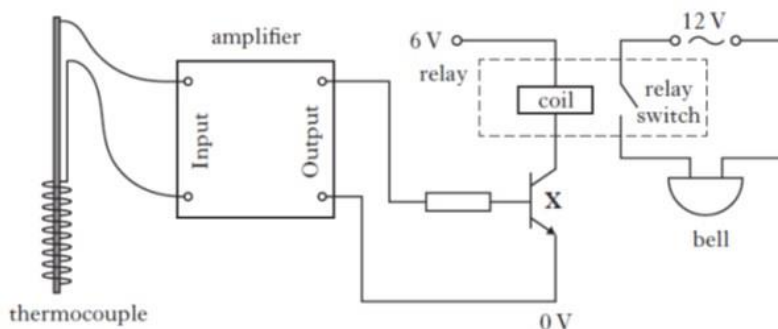
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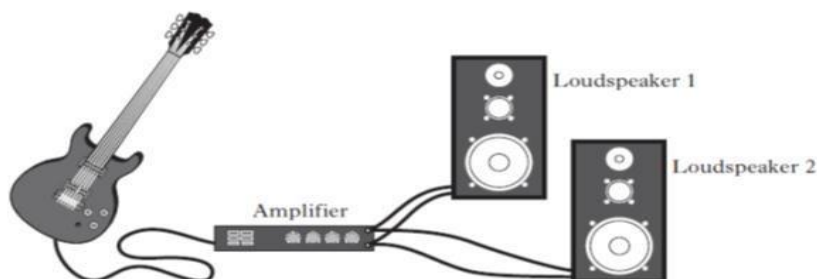
5. Which of the following devices converts electrical energy to kinetic energy?
- A Motor
  - B Lamp
  - C LED
  - D LDR
  - E Microphone

1

6. A student designs a circuit to act as a high temperature warning device.



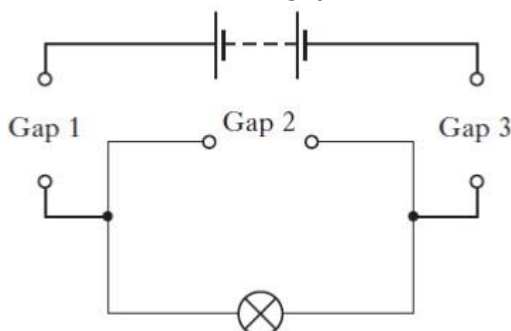
- Name component X. 1
- Explain how the circuit operates to sound the bell when the temperature of the thermocouple reaches a certain value. 2
- The student also plays an electric guitar. The guitar is connected to a Different amplifier and two loudspeakers as shown. 2



Each loudspeaker has a resistance of  $16\ \Omega$ .

Calculate the combined resistance of the two loudspeakers when connected as shown. 3

7. A circuit with three gaps is shown below.

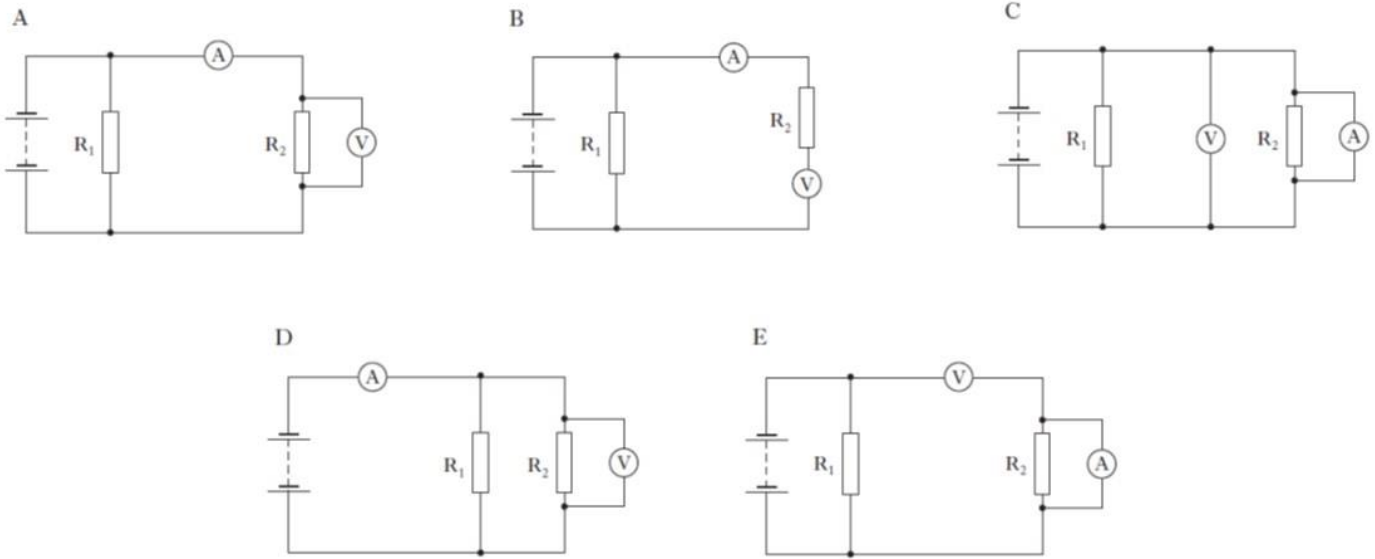


Which row in the table shows the combination of conductors and insulators that should be placed in the gaps to allow the lamp to light? 1

	Gap 1	Gap 2	Gap 3
A	Conductor	Insulator	Conductor
B	Conductor	Conductor	Insulator
C	Conductor	Conductor	Conductor
D	Insulator	Insulator	Conductor
E	Insulator	Insulator	Insulator

8. In which circuit below would the meter readings allow the resistance of  $R_2$  to be calculated?

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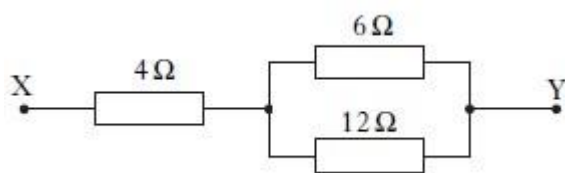


9. Which of the following devices converts heat energy into electrical energy?

- A Solar cell
- B Resistor
- C Thermocouple
- D Thermistor
- E Transistor

1

10. Three resistors are connected as shown.

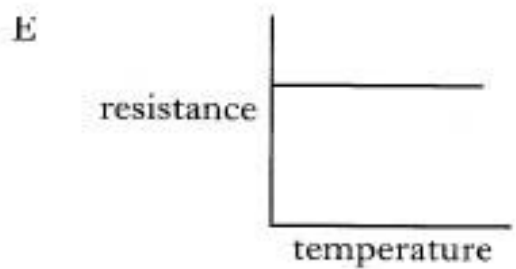
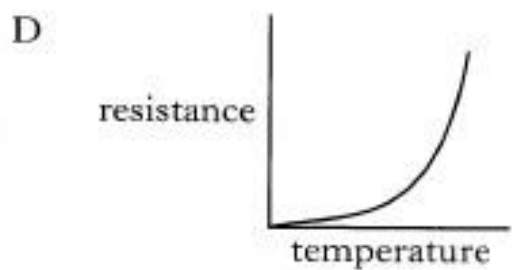
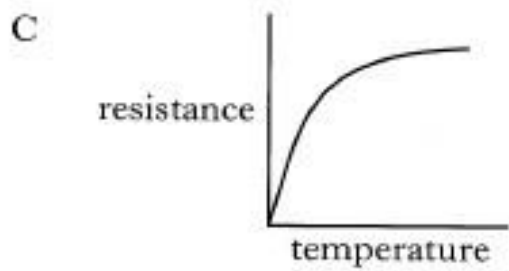
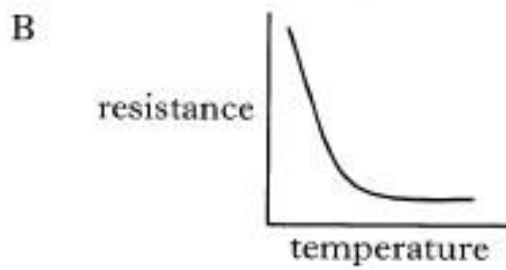
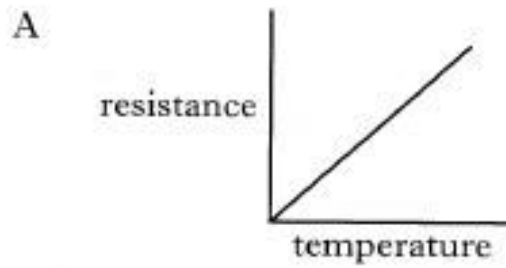


The total resistance between X and Y is

- A  $2\ \Omega$
- B  $4\ \Omega$
- C  $8\ \Omega$
- D  $13\ \Omega$
- E  $22\ \Omega$ .

1

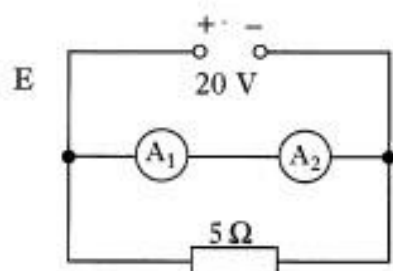
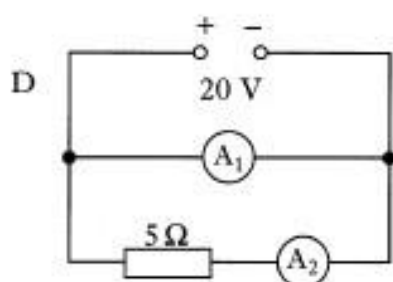
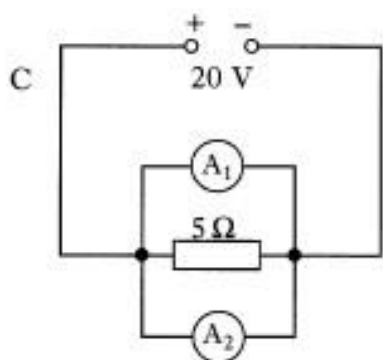
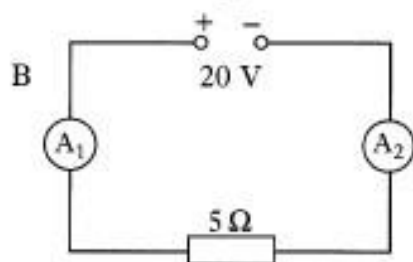
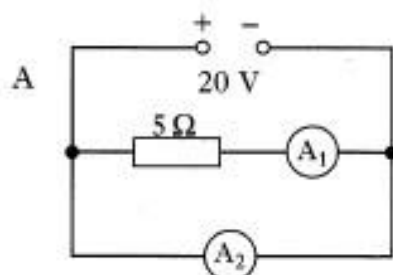
11. Which graph shows how the resistance of most thermistors varies with temperature? 1



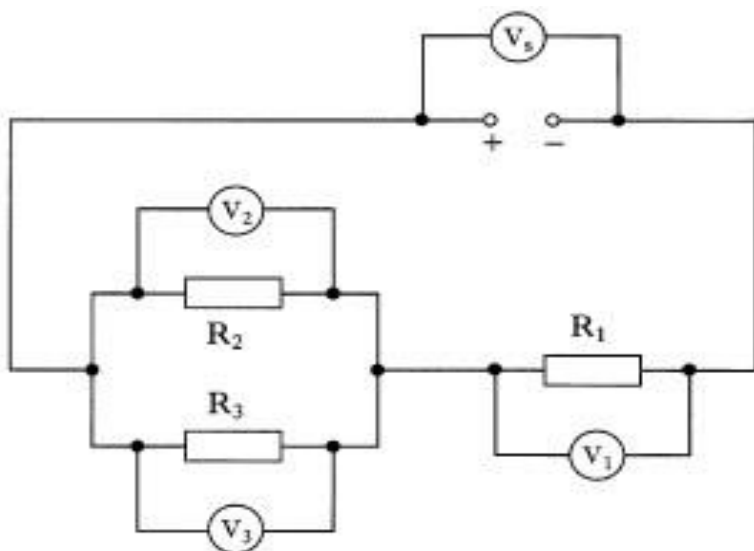
12. A student suspects that ammeter  $A_1$  may be inaccurate. Ammeter  $A_2$  is known to be accurate.

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

1



13. A circuit is set up as shown.



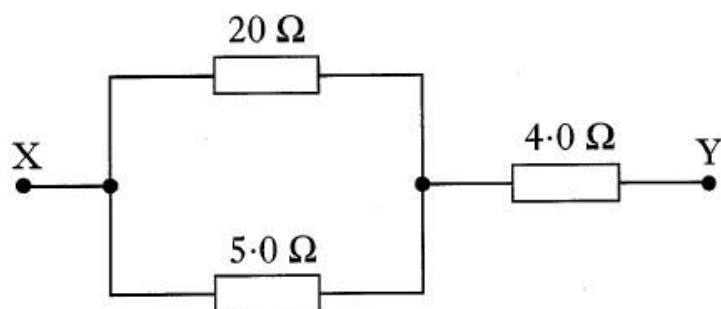
Which of the following statements about the readings on the voltmeters must always be true?

- I  $V_1 = V_2$
- II  $V_2 = V_3$
- III  $V_5 = V_1 + V_2$

- A II only
- B I and II only
- C I and III only
- D II and III only
- E I, II and III

1

14. Three resistors are connected as shown.



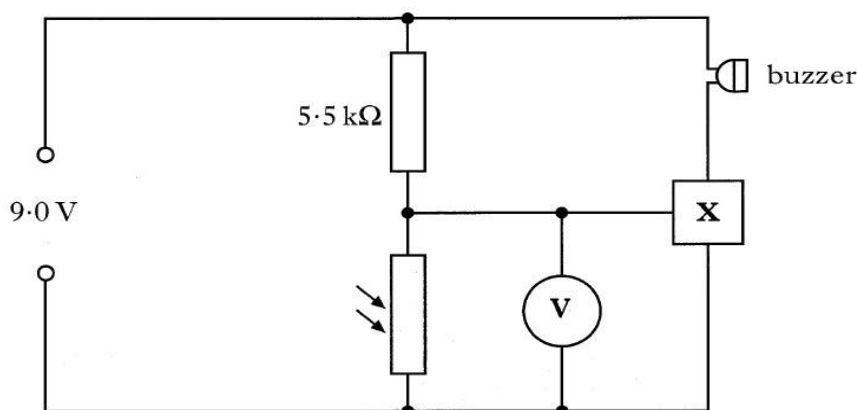
The resistance between X and Y is

- A  $0.5 \Omega$
- B  $2.0 \Omega$
- C  $4.25 \Omega$
- D  $8.0 \Omega$
- E  $29 \Omega$

1



15. A circuit diagram of an electronic system is shown below.  
The system is designed to sound a warning when the light intensity falls below a certain level.



(a) Component X is a transistor.

Two types of transistor are suitable for this system, an NPN transistor and an n-channel enhancement MOSFET.

Draw and name the circuit symbol for each transistor.

2

(b) What is the purpose of the transistor in this system?

1

(c) A MOSFET is used at position X.

When the light intensity falls, the voltmeter reading rises to 2.4V and the buzzer sounds.

Calculate the resistance of the LDR when this happens.

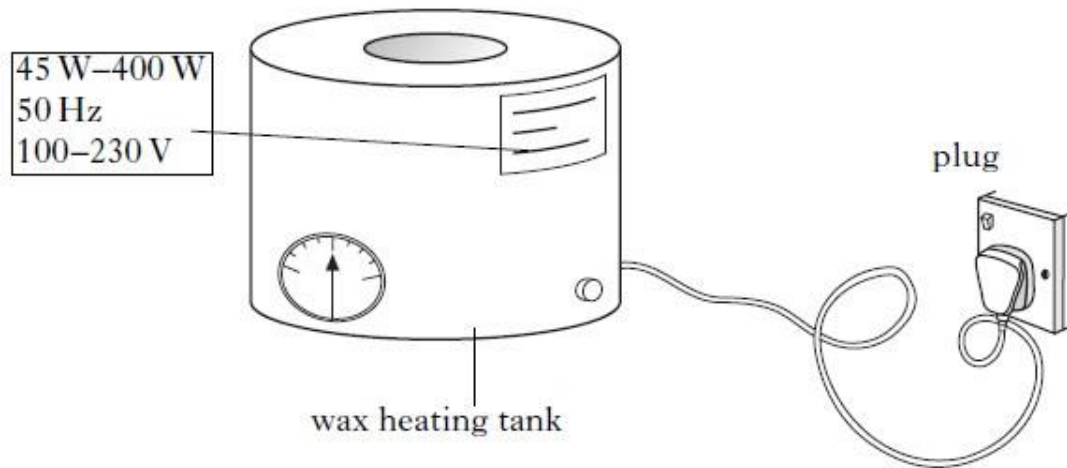
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16. Which row in the table shows the symbols for an LED and an NPN transistor?

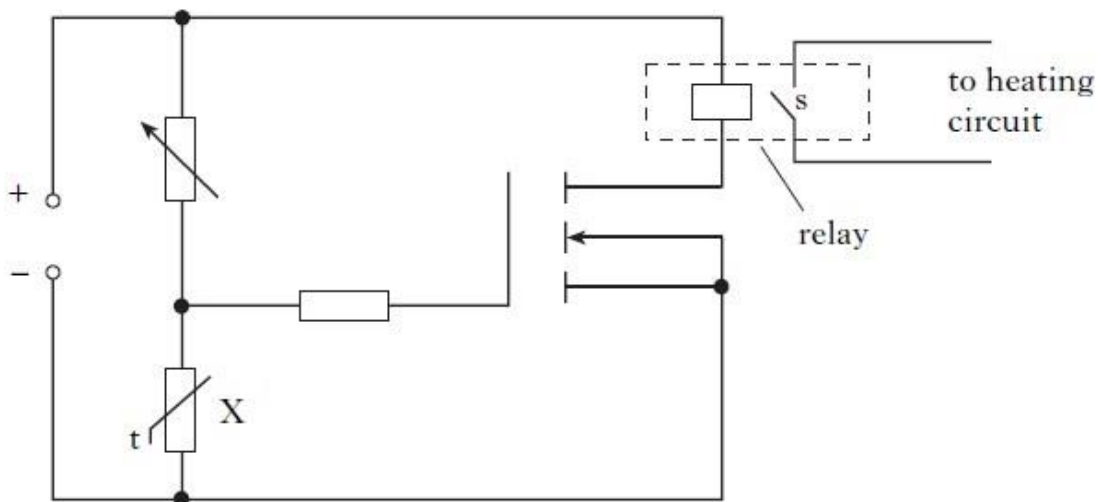
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	<i>LED</i>	<i>NPN transistor</i>
A		
B		
C		
D		
E		

17. At a beauty salon, a beautician uses hot wax to help remove hair from a client's leg. It is very important that the wax remains at a constant temperature in the heating tank.



When the wax drops below a certain temperature, a heater is automatically switched on. A simplified circuit is shown.



(a) Name component X.

1

(b) Explain how the circuit works to switch the heater on.

3

(c) What is the purpose of the variable resistor?

1

## Electrical Power

2011 Int2 4 MC

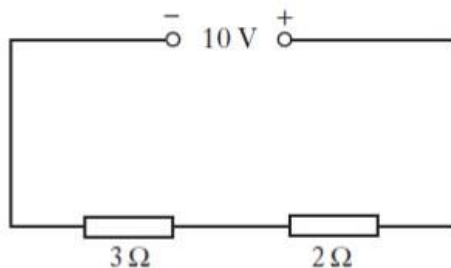
1. An engine applies a force of 2000 N to move a lorry at a constant speed. The lorry travels 100 m in 16 s. The power developed by the engine is

A 0.8 W  
B 12.5 W  
C 320 W  
D 12500 W  
E 3200000 W

1

Int2 7 MC

2. A circuit is set up as shown.



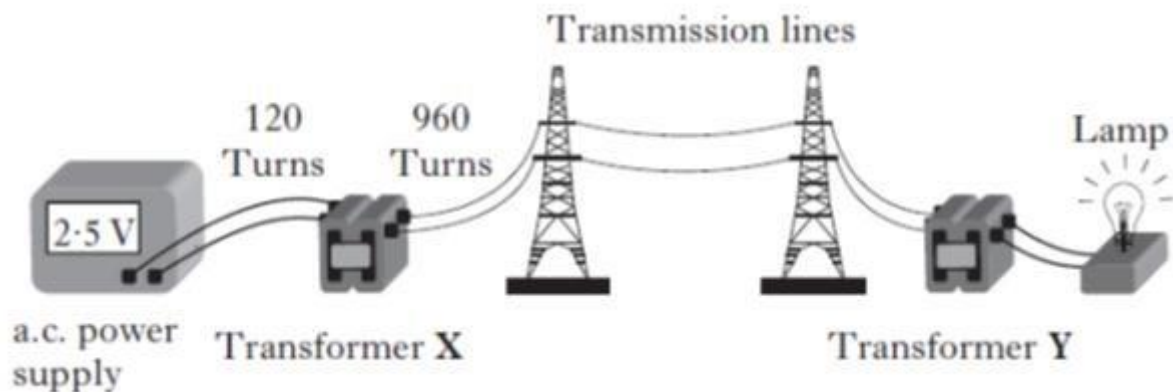
The potential difference across the 2 Ω resistor is

A 4 V  
B 5 V  
C 6 V  
D 10 V  
E 20 V

1

2012 C 11c

3. Model power transmission lines are set up to demonstrate how electricity is distributed from a power station to consumers.



The current in the transmission lines is 200 mA. The transmission lines have a total resistance of 20 Ω.

Calculate the total power loss in these transmission lines.

3

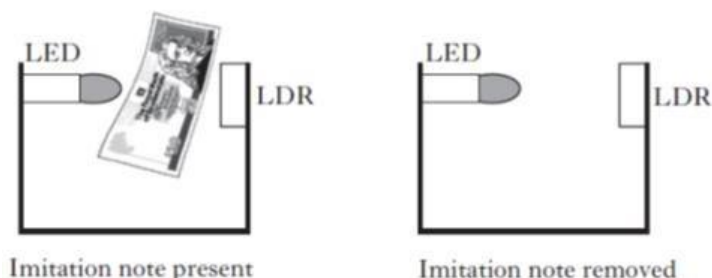
4.

A bank has an alarm system which can be triggered by the cashiers who work behind the counter.



The alarm is triggered when the cashier removes an imitation £20 note from a cash drawer.

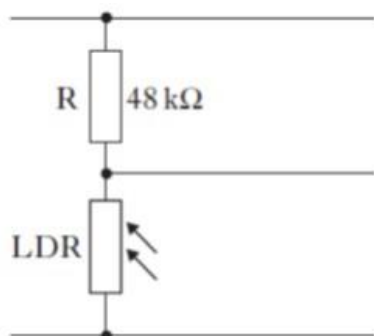
A circuit, inside the cash drawer, contains an LED which is directed at an LDR as shown. When the cashier removes the imitation £20 note the alarm is triggered.



The table shows the resistance of the LDR in different light conditions.

<i>Imitation £20 note</i>	<i>Resistance (k<math>\Omega</math>)</i>
present	24
removed	2

Part of the cash drawer circuit is shown below.



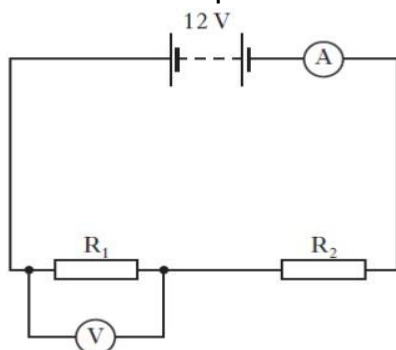
- (a) When the imitation £20 note is removed from the drawer, the voltage across the LDR is 0.36 V.  
Calculate the voltage across R. 3
- (b) The alarm has a loudspeaker as an output device, which emits a sound when The alarm is triggered. The loudspeaker has a resistance of  $48 \Omega$  and a power of 3.0 W.  
Calculate the voltage across the loudspeaker when it sounds. 3

5. A patient in a hospital has laser eye surgery. The laser used in the procedure produces 250 pulses of light per second. Each light pulse transfers 60 mJ of energy. Calculate the average power produced by each pulse of light.

4

2013 Int2 10 MC

6. A circuit is set up as shown.



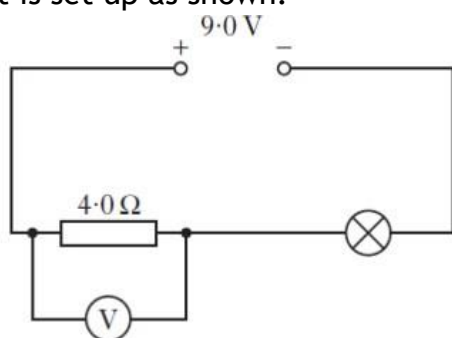
The reading on the ammeter is 3.0 A. The reading on the voltmeter is 4.0 V. Which row in the table shows the current in resistor R2 and the voltage across resistor R2?

1

	Current in resistor R <sub>2</sub> (A)	Voltage across resistor R <sub>2</sub> (A)
A	1.5	8.0
B	3.0	4.0
C	3.0	8.0
D	1.5	12.0
E	6.0	4.0

2013 Int2 11MC

7. A circuit is set up as shown.



The current in the lamp is 1.5 A. The reading on the voltmeter is 6.0 V. 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

1

8. The resistance of a wire is  $6\ \Omega$ .  
The current in the wire is 2A.  
The power developed in the wire is
- A 3W
  - B 12W
  - C 18W
  - D 24W
  - E 72W.

1

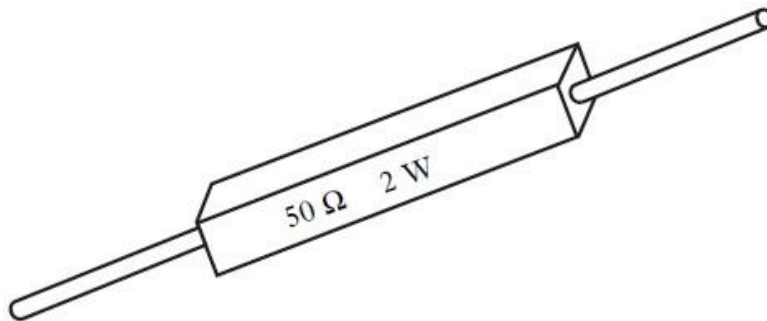
2007 C 4bi

9. A 25 W lamp is designed to be used with mains voltage.  
Calculate the resistance of the lamp.

4

2008 Int2 25a

10. 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.



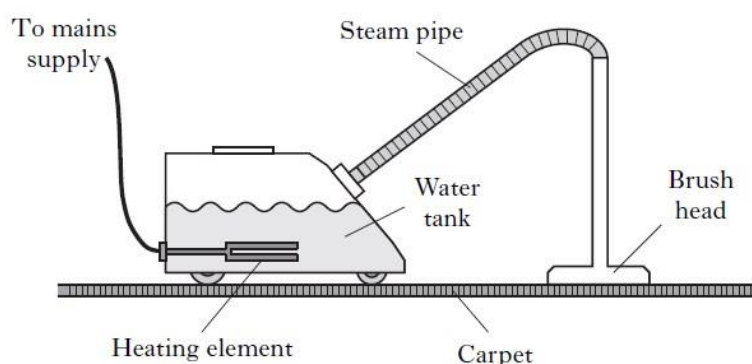
- A resistor is labelled  $50\Omega$ , 2W.  
Calculate the maximum operating current for this resistor.

3

## Specific Heat Capacity

2011 C 11

1. A steam cleaner is used to clean a carpet. The water tank is filled with 1.6 kg of water at 20 °C. This water is heated until it boils and produces steam. The brush head is pushed across the surface of the carpet and steam is released.

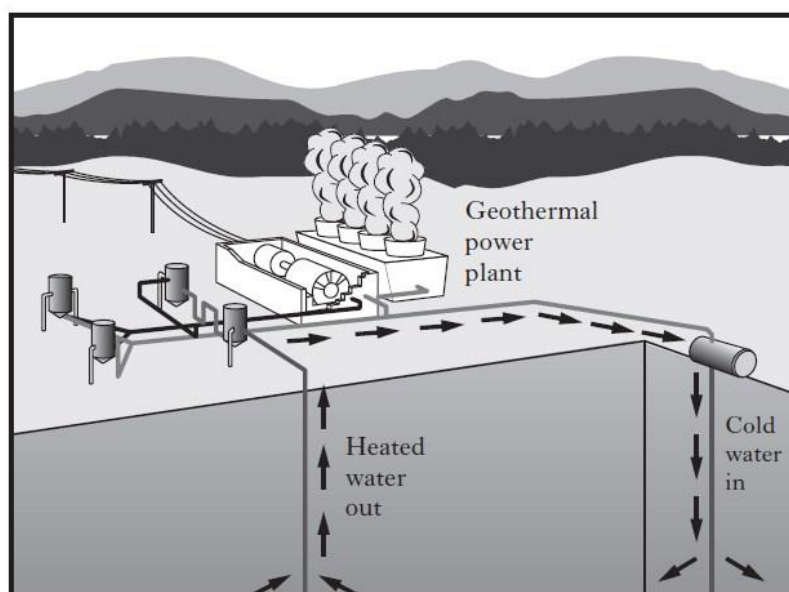


Calculate how much heat energy is needed to bring this water to its boiling point of 100 °C.

4

2013 C 12

2. An experimental geothermal power plant uses heat energy from deep underground to produce electrical energy. A pump forces water at high pressure down a pipe. The water is heated and returns to the surface. At this high pressure the boiling point of water is 180 °C.



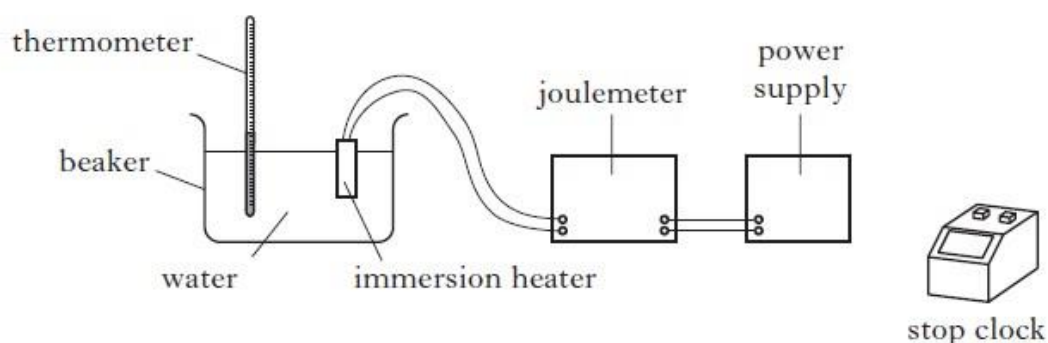
The plant is designed to pump 82 kg of heated water, to the surface, each second. The specific heat capacity of this water is 4320 J kg<sup>-1</sup> °C<sup>-1</sup>.

The water enters the ground at 20 °C and emerges at 145 °C.

Calculate the heat energy absorbed by the water each second.

3

3. An experiment was carried out to determine the specific heat capacity of water. The energy supplied to the water was measured by a joulemeter.



The following data was recorded.

Initial temperature of the water = 21 °C.

Final temperature of the water = 33 °C.

Initial reading on the joulemeter = 12 kJ.

Final reading on the joulemeter = 120 kJ.

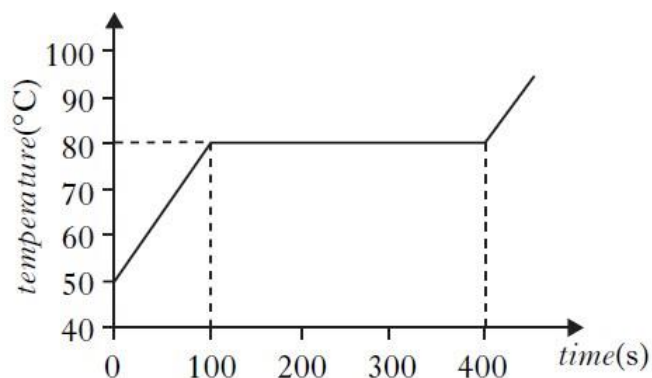
Mass of water = 2.0 kg.

Time = 5 minutes.

- |     |       |   |   |
|-----|-------|---|---|
| (a) | (i)   | Calculate the change in temperature of the water.   | 1 |
|     | (ii)  | Calculate the energy supplied by the immersion heater.  | 1 |
|     | (iii) | Calculate the value for the specific heat capacity of water obtained from this experiment.  | 3 |
| (b) | (i)   | The accepted value for the specific heat capacity of water is quoted in the table in the Data Sheet.<br>Explain the difference between the accepted value and the value obtained in the experiment. | 2 |
|     | (ii)  | State how the experiment could be improved to reduce this difference.   | 1 |
| (c) |       | Calculate the power rating of the immersion heater.   | 3 |



4. 100 g of a solid is heated by a 50W heater. The graph of temperature of the substance against time is shown.



The specific latent heat of fusion of the substance is

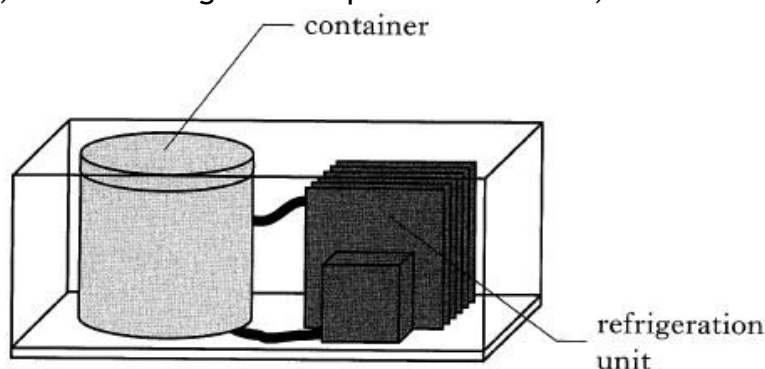
- A  $1.3 \times 10^3 \text{ Jkg}^{-1}$
- B  $1.5 \times 10^3 \text{ Jkg}^{-1}$
- C  $3.0 \times 10^3 \text{ Jkg}^{-1}$
- D  $1.5 \times 10^5 \text{ Jkg}^{-1}$
- E  $1.9 \times 10^5 \text{ Jkg}^{-1}$ . 1

5. On the planet Mercury the surface temperature at night is  $-173^\circ\text{C}$ . The surface temperature during the day is  $307^\circ\text{C}$ . A rock lying on the surface of the planet has a mass of 60 kg.



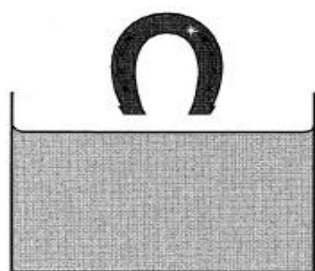
- (a) The rock absorbs  $2.59 \times 10^7 \text{ J}$  of heat energy from the Sun during the day.  
Calculate the specific heat capacity of the rock. 3
- (b) Heat is released at a steady rate of  $1440 \text{ J/s}$  at night.  
Calculate the time taken for the rock to release  $2.59 \times 10^7 \text{ J}$  of heat. 3
- (c) Energy from these rocks could be used to heat a base on the surface of Mercury.  
How many 60 kg rocks would be needed to supply a 288 kW heating system? 3

6. An ice cream maker has a refrigeration unit which can remove heat at  $120 \text{ Js}^{-1}$ . Liquid ice cream, of mass  $0.6 \text{ kg}$  at a temperature of  $20^\circ\text{C}$ , is added to the container.



- (a) Calculate how much energy must be removed from the mixture to cool it to its freezing point of  $-16^\circ\text{C}$ .  
(Specific heat capacity of ice cream =  $2100 \text{ J kg}^{-1} ^\circ\text{C}^{-1}$ ) 3
- (b) Calculate how much heat energy must be removed to freeze the ice cream at this temperature.  
(Specific latent heat of fusion of ice cream =  $2.34 \times 10^5 \text{ J kg}^{-1}$ ) 3
- (c) (i) Calculate the time taken to cool and freeze the ice cream. 4
- (ii) What assumption have you made in carrying out this calculation? 1

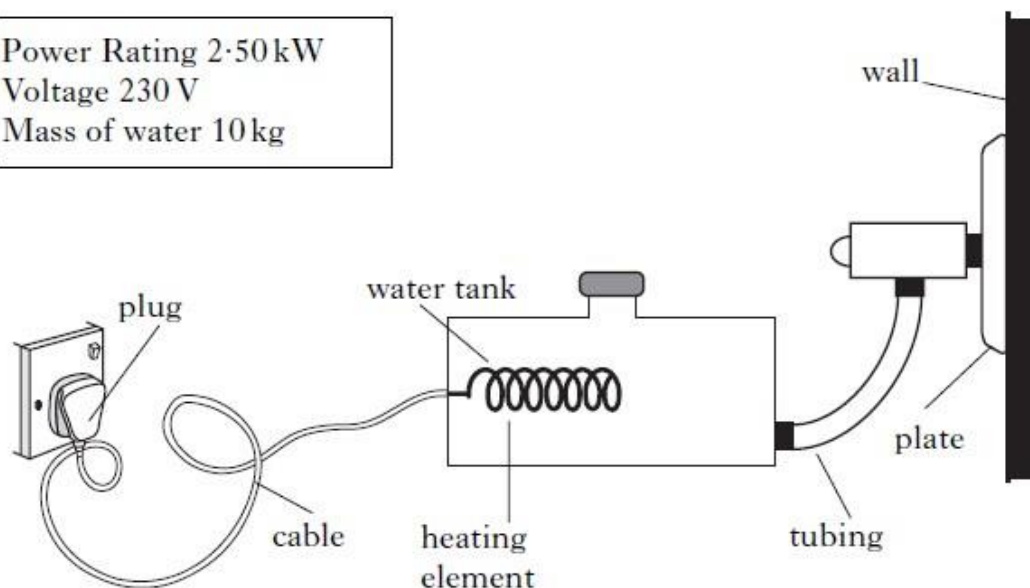
7. A blacksmith cools a hot iron horse-shoe of mass  $0.75 \text{ kg}$  by dropping it into water. The mass of the water is  $15 \text{ kg}$  and its initial temperature is  $17^\circ\text{C}$ . Heat energy from the iron warms the water until both the iron and the water are at  $23^\circ\text{C}$ .



- (a) Calculate the heat energy absorbed by the water. 3
- (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. 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.

Power Rating 2.50 kW  
Voltage 230 V  
Mass of water 10 kg



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

- (a) Calculate the energy required to bring the water to its boiling point. 3
- (b) Calculate the time taken for this to happen. 3
- (c) The actual time taken for this to happen was found to be longer than that calculated in (b). Explain why. 1

## Gas Laws and the Kinetic Model

2013 H 7MC

1. The pressure of a gas in a sealed syringe is  $1.5 \times 10^5$  Pa.  
The temperature of the gas is  $27^\circ\text{C}$ .  
The temperature of the gas is now raised by  $10^\circ\text{C}$  and the volume of the gas halved.

The new pressure of the gas in the syringe is

A  $1.1 \times 10^5$  Pa

B  $2.8 \times 10^5$  Pa

C  $3.1 \times 10^5$  Pa

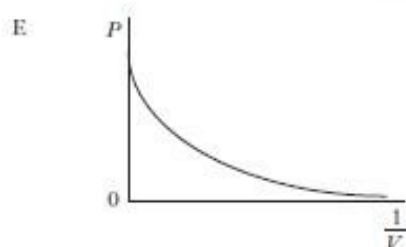
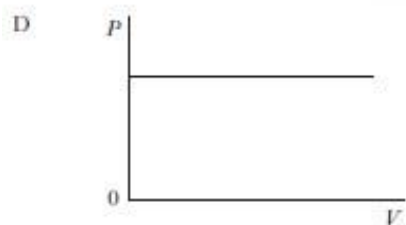
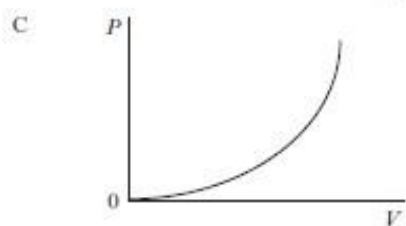
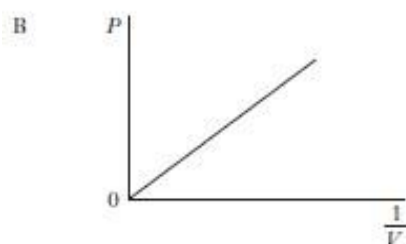
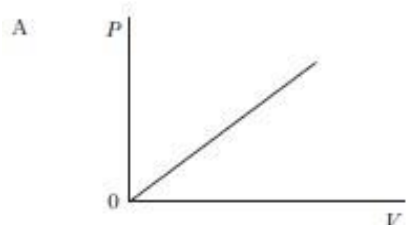
D  $4.1 \times 10^5$  Pa

E  $11 \times 10^5$  Pa.

1

2012 H 7MC

2. Which of the following graphs shows the relationship between the pressure  $P$  and the volume  $V$  of a fixed mass of gas at constant temperature?



1

2011 H 5M

3. An aircraft cruises at an altitude at which the external air pressure is  $0.40 \times 10^5$  Pa. The air pressure inside the aircraft cabin is maintained at  $1.0 \times 10^5$  Pa. The area of an external cabin door is  $2.0 \text{ m}^2$ . What is the outward force on the door due to the pressure difference?

- A  $0.30 \times 10^5$  N  
B  $0.70 \times 10^5$  N  
C  $1.2 \times 10^5$  N  
D  $2.0 \times 10^5$  N  
E  $2.8 \times 10^5$  N

2011 H 7MC

4. A fixed mass of gas is heated inside a rigid container. As its temperature changes from  $T_1$  to  $T_2$  the pressure increases from  $1.0 \times 10^5$  Pa to  $2.0 \times 10^5$  Pa. Which row in the table shows possible values for  $T_1$  and  $T_2$ ?

	$T_1$	$T_2$
A	27 °C	327 °C
B	30 °C	60 °C
C	80 °C	40 °C
D	303 K	333 K
E	600 K	300 K

2009 H 6MC

5. The density of the gas in a container is initially  $5.0 \text{ kg m}^{-3}$ . Which of the following increases the density of the gas?

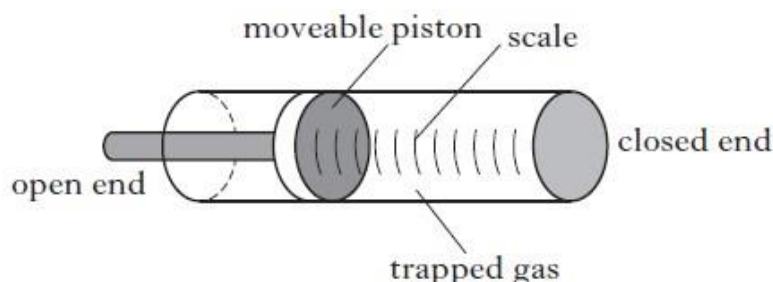
- I Raising the temperature of the gas without changing its mass or volume.  
II Increasing the mass of the gas without changing its volume or temperature.  
III Increasing the volume of the gas without changing its mass or temperature.

- A II only  
B III only  
C I and II only  
D II and III only  
E I, II and III

2008 H 7MC

6. One pascal is equivalent to  
A 1 Nm  
B  $1 \text{ Nm}^2$   
C  $1 \text{ Nm}^3$   
D  $1 \text{ Nm}^{-2}$   
E  $1 \text{ Nm}^{-3}$ .

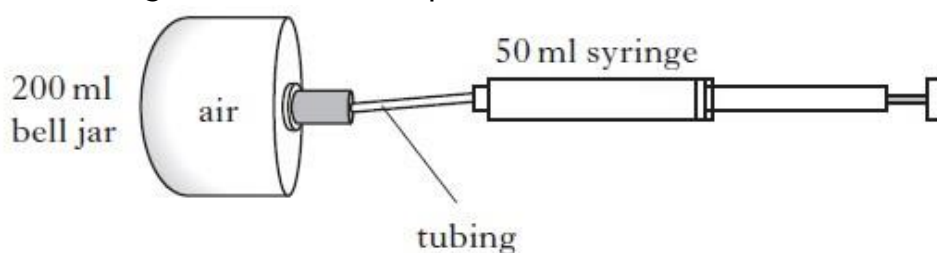
7. A diver is measuring the pressure at different depths in the sea using a simple pressure gauge. Part of the pressure gauge consists of a cylinder containing gas trapped by a moveable piston.



At sea level, the atmospheric pressure is  $1.01 \times 10^5$  Pa and the trapped gas exerts a force of 262 N on the piston.

- (a) Calculate the area of the piston. 3
- (b) The diver now descends to a depth,  $h$ , where the gauge registers a total pressure of  $5.13 \times 10^5$  Pa. The temperature of the trapped gas remains constant. While at this depth, a bubble of gas is released from the diver's breathing apparatus. State what happens to the volume of this bubble as it rises to the surface. Justify your answer. 1

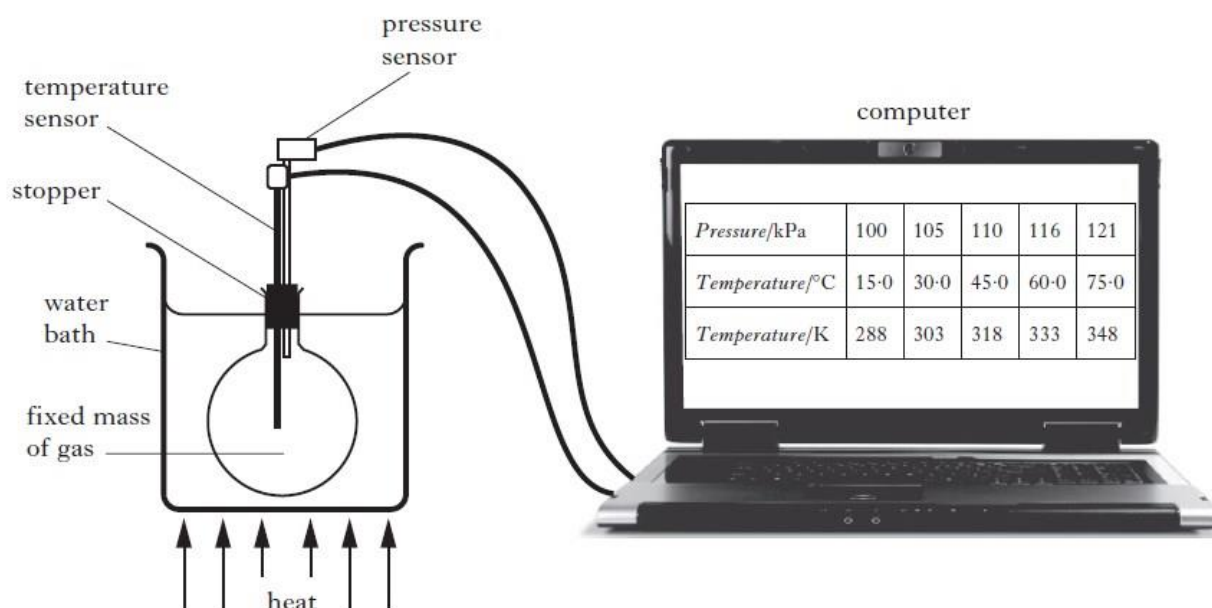
8. A technician uses the equipment shown to investigate the relationship between the volume and pressure of a gas at constant temperature.



The pressure in the bell jar is  $1.01 \times 10^5$  Pa.

- (a) The technician uses a syringe to remove 50 ml of the air from the bell jar. Calculate the new pressure of the air inside the bell jar. 3
- (b) Use the kinetic model to explain this change in pressure after removing air with the syringe. 4

9. A student carries out an experiment to investigate the relationship between the pressure and temperature of a fixed mass of gas. The apparatus used is shown.



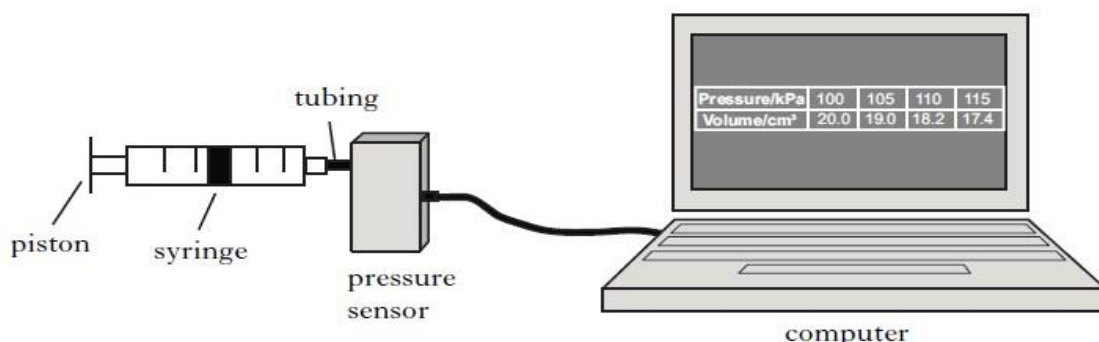
The pressure and temperature of the gas are recorded using sensors connected to a computer. The gas is heated slowly in the water bath and a series of readings is taken. The volume of the gas remains constant during the experiment. The results are shown.

<i>Pressure/kPa</i>	100	105	110	116	121
<i>Temperature/°C</i>	15.0	30.0	45.0	60.0	75.0
<i>Temperature/K</i>	288	303	318	333	348

- Using all the relevant data, establish the relationship between the pressure and the temperature of the gas. 2
- Use the kinetic model to explain the change in pressure as the temperature of the gas increases. 3
- Explain why the level of water in the water bath should be above the bottom of the stopper. 1

10. A student is training to become a diver.

- (a) The student carries out an experiment to investigate the relationship between the pressure and volume of a fixed mass of gas using the apparatus shown.



The pressure of the gas is recorded using a pressure sensor connected to a computer. The volume of the gas is also recorded. The student pushes the piston to alter the volume and a series of readings is taken.

The temperature of the gas is constant during the experiment.

The results are shown.

Pressure/kPa	100	105	110	115
Volume/cm <sup>3</sup>	20.0	19.0	18.2	17.4

- (i) Using all the data, establish the relationship between the pressure and volume of the gas. 2
- (ii) Use the kinetic model to explain the change in pressure as the volume of gas decreases. 3
- (b) The diver goes to dive in a loch. At a depth of 12.0 m, the total pressure is  $2.21 \times 10^5 \text{ Pa}$ . the diver fills her lungs with air from her breathing apparatus. She then swims to the surface. 3
- Explain why it would be dangerous for her to hold her breath while doing this.

**2008 H 23ai**

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



The oxygen inside the cylinder is at a pressure of  $2.82 \times 10^6 \text{ Pa}$  and a temperature of  $19.0^\circ \text{C}$ .

The cylinder is now moved to a storage room where the temperature is  $5.0^\circ \text{C}$ . Calculate the pressure of the oxygen inside the cylinder when its temperature is  $5.0^\circ \text{C}$ .

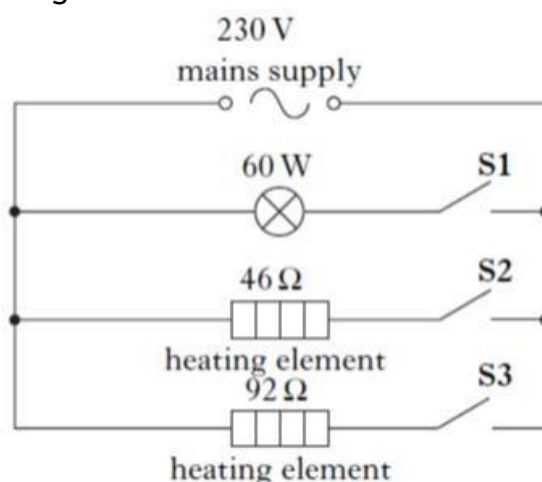
3



1. A mains electric fire has two heating elements which can be switched on and off separately. The heating elements can be switched on to produce three different heat settings: LOW, MEDIUM and HIGH. The fire also has an interior lamp which can be switched on to give a log-burning effect.

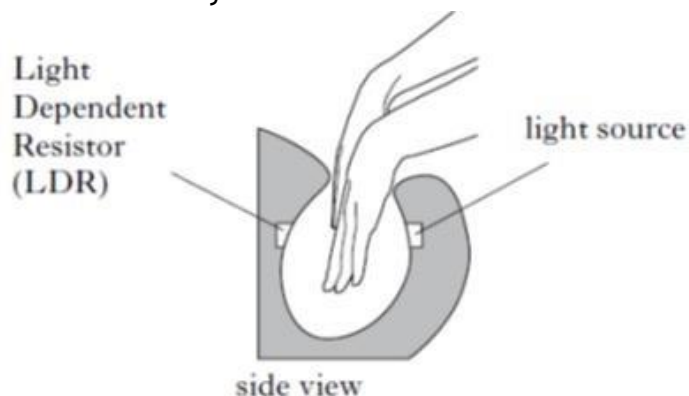


The circuit diagram for the fire is shown.



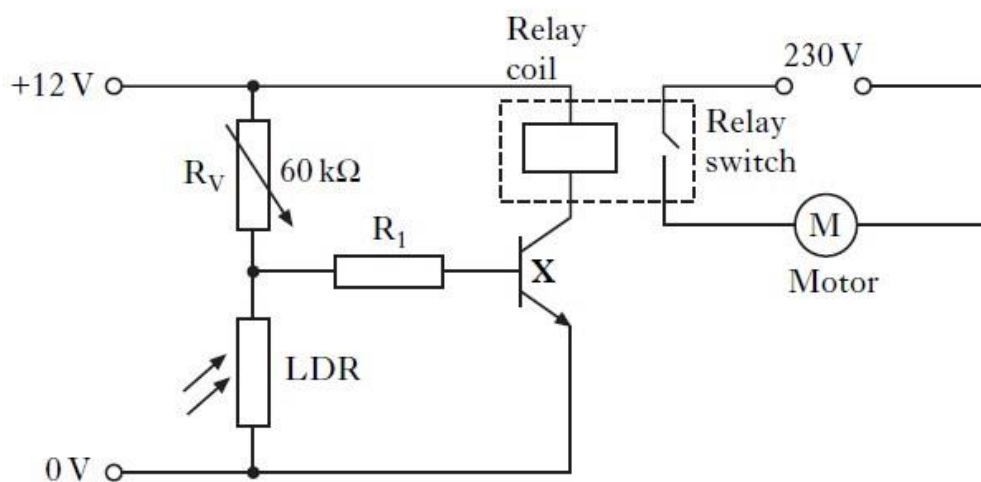
- (a) When switch S1 is closed, the lamp operates at its stated rating of 60W. Calculate the current in the lamp. 3
- (b) Switch S1 is opened and switches S2 and S3 are closed.
- (i) Calculate the combined resistance of both heating elements. 3
- (ii) Calculate the total power developed in the heating elements when S2 and S3 are closed. 3
- (iii) (A) State which switch or switches would have to be closed to produce the LOW heat setting. 1
- (B) Explain your answer to (b) (iii) (A). 1

2. An automatic hand dryer used in a washroom is shown in the diagram below.



Inserting hands into the dryer breaks a light beam, this is detected using a light dependent resistor (LDR). The LDR is part of a switching circuit which activates the dryer when hands are inserted.

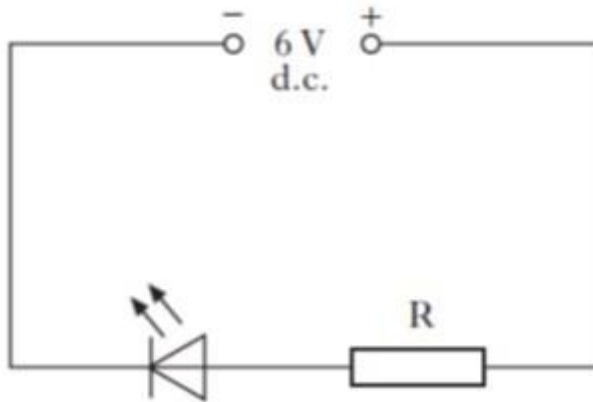
Part of the circuit for the hand dryer is shown.



- The variable resistor  $R_V$  is set to a resistance of  $60\text{ k}\Omega$ . Calculate the voltage across the LDR when its resistance is  $4\text{ k}\Omega$ . 3
- Name component X in the circuit diagram. 1
- Explain how this circuit operates to activate the motor in the dryer when the light level falls below a certain value. 2

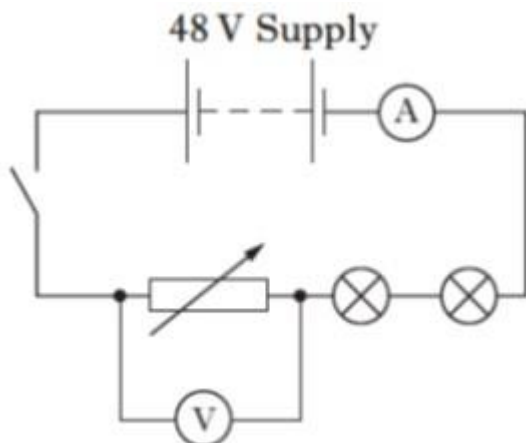
3. Light emitting diodes (LEDs) are often used as on/off indicators on televisions and computers.

An LED is connected in a circuit with a resistor R.

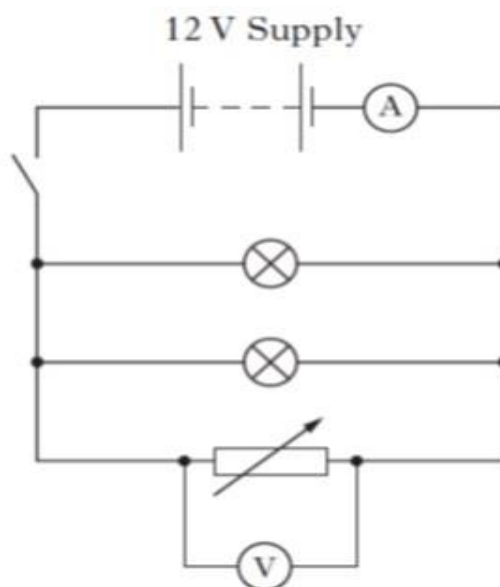


- |     |   |   |
|-----|---|---|
| (a) | State the purpose of resistor R.  | 1 |
| (b) | The LED is rated at 2 V, 100 mA.<br>Calculate the resistance of resistor R.   | 4 |
| (c) | Calculate the power developed by resistor R when the LED is working normally. | 3 |

4. A student sets up a circuit to operate two identical 12 V, 36 W lamps from a 48 V supply.



- (a) When the switch is closed, the lamps operate at their correct power rating. Calculate:
- the reading on the ammeter; 3
  - the reading on the voltmeter; 1
  - the resistance of the variable resistor. 3
- (b) The student sets up a second circuit using a 12 V supply and the same lamps. Each lamp has a resistance of  $4\ \Omega$ . The resistance of the variable resistor is set to  $6\ \Omega$ .

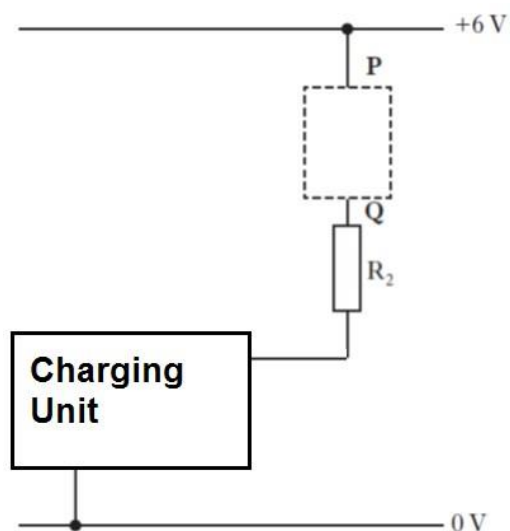


- Calculate the total resistance of this circuit. 3
- The variable resistor is now removed from the circuit.
  - State what happens to the reading on the ammeter. 1
  - Explain your answer. 1

5. A laptop is plugged into the mains to charge.  
An LED lights to indicate that the laptop is charging.

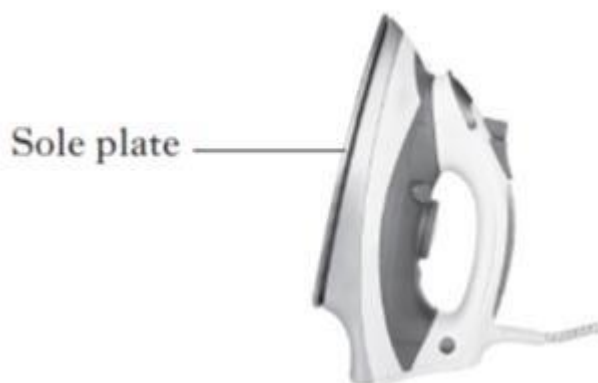


The LED is connected to a pulse generator.  
The circuit diagram for this is shown



- Complete the diagram to show the LED correctly connected between P and Q. 1
- State the purpose of resistor  $R_2$  connected in series with the LED. 1
- When lit, the current in the LED is 15 mA and the voltage across it is 1.2 V.  
Calculate the value of resistor  $R_2$  in series with the LED. 4

6. A manufacturer has developed an iron with an aluminium sole plate. A technician has been asked to test the iron.

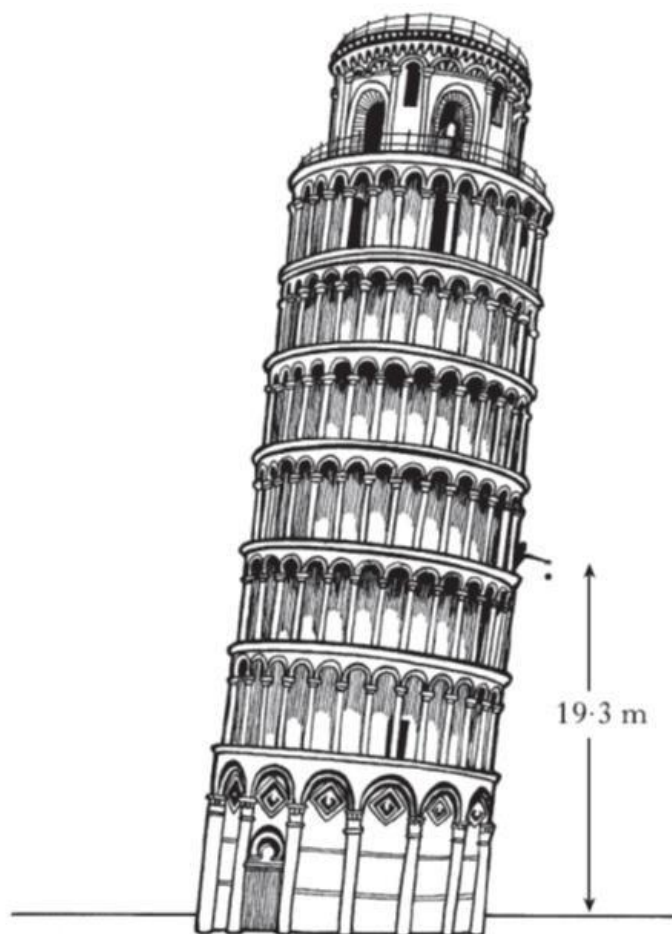


The technician obtains the following data for one setting of the iron.

Starting temperature of sole plate:  $24\text{ }^{\circ}\text{C}$   
 Operating temperature of the sole plate:  $200\text{ }^{\circ}\text{C}$   
 Time for iron to reach the operating temperature:  $35\text{ s}$   
 Power rating of the iron:  $1.5\text{ kW}$   
 Operating voltage:  $230\text{ V}$   
 Specific Heat Capacity of Aluminium:  $902\text{ J kg}^{-1}\text{ }^{\circ}\text{C}^{-1}$

- (a) Calculate how much electrical energy is supplied to the iron in this time. 3
- (b) Calculate the mass of the aluminium sole plate. 3
- (c) The actual mass of the aluminium sole plate is less than the value calculated in part (b) using the technician's data. in
- State one reason for this difference. 1

7. A student reproduces Galileo's famous experiment by dropping a solid copper ball of mass  $0.50 \text{ kg}$  from a balcony on the Leaning Tower of Pisa.



- (a) The ball is released from a height of  $19.3 \text{ m}$ .  
Calculate the gravitational potential energy lost by the ball. 3
- (b) Assuming that all of this gravitational potential energy is converted into heat energy in the ball, calculate the increase in the temperature of the ball on impact with the ground. 3
- (c) (i) State if the actual temperature change of the ball is greater than, the same as or less than the value calculated in part (a)(ii). 1
- (ii) You must explain your answer to part (c) (i). 1

8. A resistor is labelled: “ $10\ \Omega \pm 10\%$ , 3 W”.

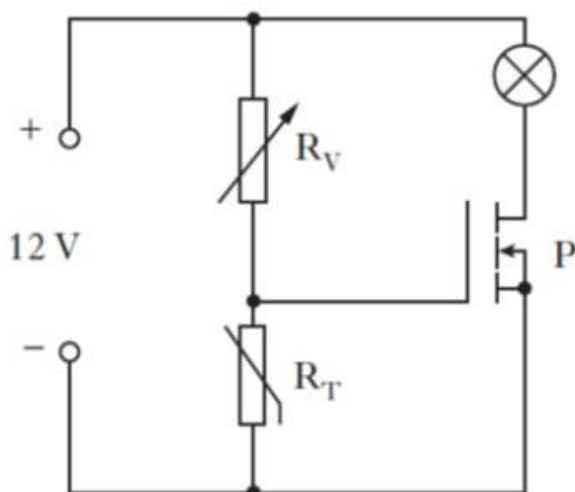


This means that the resistance value could actually be between  $9\ \Omega$  and  $11\ \Omega$ .

- (a) A student decides to check the value of the resistance.  
Draw a circuit diagram, including a 6 V battery, a voltmeter and an ammeter, for a circuit that could be used to determine the resistance. 3
- (b) Readings from the circuit give the voltage across the resistor as  $5.7\ \text{V}$  and the current in the resistor as  $0.60\ \text{A}$ .  
Use these values to calculate the resistance. 3
- (c) During this experiment, the resistor becomes very hot and gives off smoke. The student states that two of these resistors would not have overheated if they were connected together in parallel with the battery.
- (i) State if the student is correct. 1
- (ii) Explain your answer to part (c) (i). 1

2012 Int2 25ab

9. The circuit shown switches a warning lamp on or off depending on the temperature.

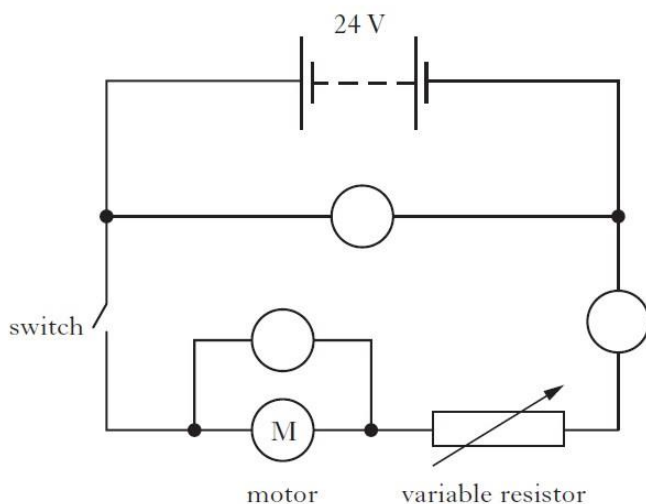


- (a) Name component P. 1
- (b) As the temperature increases the resistance of thermistor  $R_T$  decreases. State what happens to the voltage across  $R_T$  as the temperature increases? 1



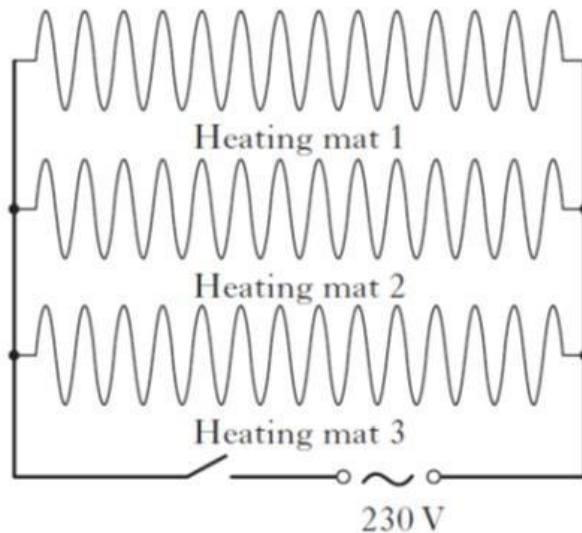
10. A student has designed a simple electric cart. The cart uses 2 large 12 V rechargeable batteries to drive an electric motor. The speed of the cart is controlled by adjusting a variable resistor.

The circuit diagram for the cart is shown.



- (a) The circuit contains two voltmeters and an ammeter.  
Complete the diagram by labelling the meters. 1
- (b) When the cart is moving at a certain speed the voltage across the motor is 18 V and the resistance of the variable resistor is  $2.1\ \Omega$ .  
Calculate the current in the motor. 4
- (c) The batteries take 10 hours to fully recharge using a constant charging current of 3.2 A.  
Calculate how much charge is transferred to the batteries in this time. 3
- (d) For the cart to be able to reverse, the motor has to rotate in the opposite direction.  
State one change which could be made to the circuit to make the motor rotate in the opposite direction. 1

11. A house owner installs a heating system under the floor of a new conservatory. Three heating mats are fitted. The mats contain resistance wires and are laid underneath the floor. Each mat is designed to operate at 230 V and has a power of 300 W.



- (a) State how the three heating mats are connected together to operate at their correct voltage.
- (b) Calculate the current in each heating mat when switched on.
- (c) Calculate the total resistance of the heating system when all three mats are switched on.

1

3

4

12. An overhead projector contains a lamp and a motor that operates a cooling fan. A technician has a choice of two lamps to fit in the projector.

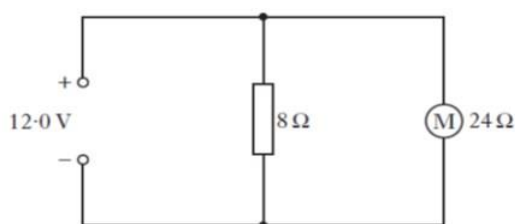
**Lamp A:** rated  $24.0\text{ V}$ ,  $2.5\ \Omega$

**Lamp B:** rated  $24.0\text{ V}$ ,  $5.4\ \Omega$



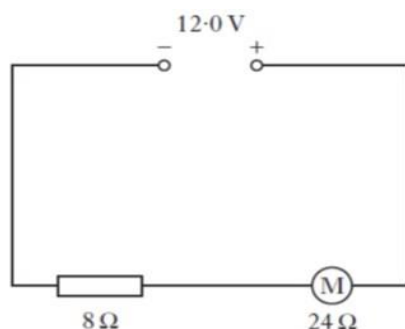
- (a) (i) State which lamp gives a brighter light when operating at the correct voltage. 1  
 (ii) Explain your answer to (a) (i). 1
- (b) Calculate the power developed by lamp A when it is operating normally. 3
- (c) The overhead projector plug contains a fuse.  
 Draw the circuit symbol for a fuse. 1

- (d) The technician builds a test circuit containing a resistor and a motor, as shown in Circuit 1.



**Circuit 1**

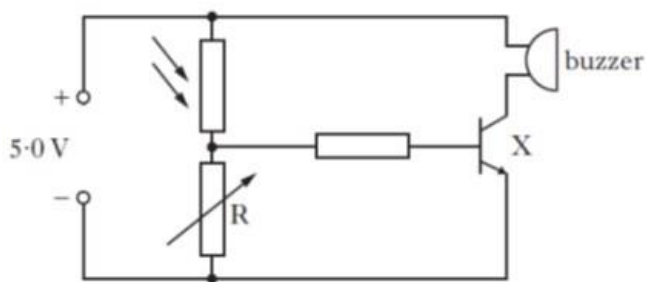
- (i) State the voltage across the motor. 1  
 (ii) Calculate the combined resistance of the resistor and the motor. 3
- (e) The resistor and the motor are now connected in series, as shown in Circuit 2.



**Circuit 2**

- (i) State how this affects the speed of the motor compared to Circuit 1. 1  
 (ii) Explain your answer to (e) (i). 1

13. A photographic darkroom has a buzzer that sounds when the light level in the room is too high. The circuit diagram for the buzzer system is shown below.



- (a) (i) Name component X. 1
- (ii) Explain the purpose of component X in the circuit 1
- (b) The darkroom door is opened and the light level increases.  
Explain how the circuit operates to sound the buzzer. 3
- (c) The table shows how the resistance of the LDR varies with light level.

<i>Light level (units)</i>	<i>LDR Resistance (<math>\Omega</math>)</i>
20	4500
50	3500
80	2500

The variable resistor has a resistance of  $570\ \Omega$ .

The light level increases to 80 units.

Calculate the current in the LDR. 4

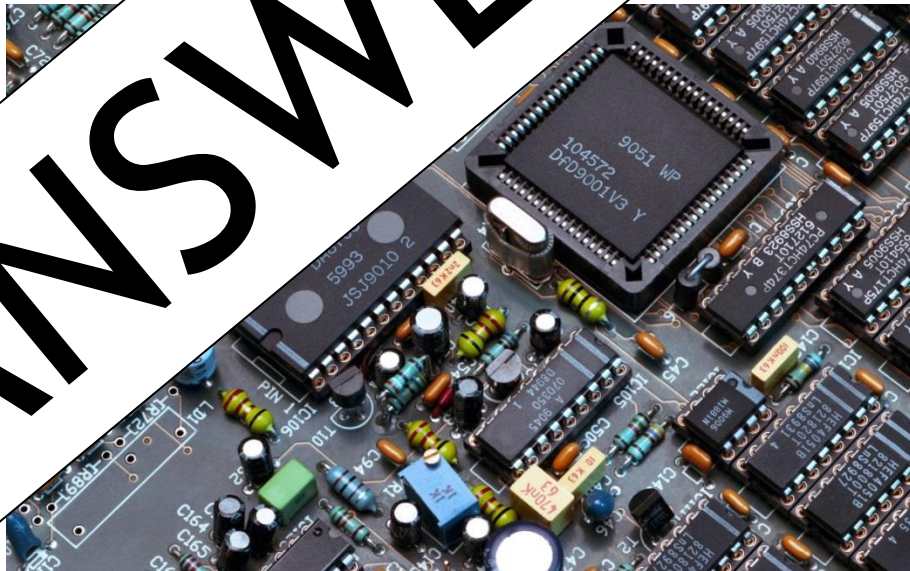
- (d) State the purpose of the variable resistor R in this circuit. 1

# NATIONAL 5 PHYSICS

Unit 1

Electricity and Energy

**ANSWERS**



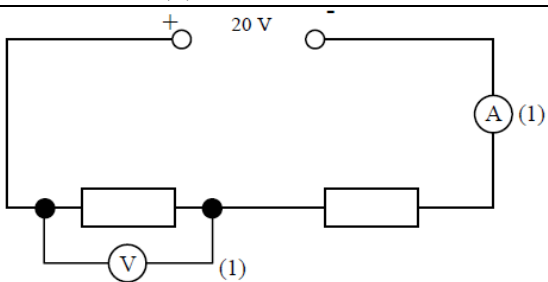
## Exam Questions


CONSERVATION OF ENERGY				
1		$E_p = m g h$ (1) $= 25 \times 9.8 \times 1.2$ (1) $= 290 \text{ J}$ (1)	3	Sf, accept 300, 294
2		C	1	
3		$E_k = \frac{1}{2} m v^2$ (1) $= 0.5 \times 1.5 \times 10^2$ (1) $= 75 \text{ J}$	3	
4		$E_p = m g h$ (1) $= 8000 \times 10 \times 500$ (1) $= 40\,000\,000 \text{ J}$ $= 40 \text{ MJ}$ (1)	3	
5	(a)	$E_p = m g h$ (1) $E_p = 750 \times 10 \times 7.2$ (1) $E_p = 54000 \text{ J}$ (1)	3	
	(b)	54000 J (1)	1	
	(i)			
	(b) (ii)	$E_k = \frac{1}{2} m v^2$ (1) $54000 = 0.5 \times 750 \times v^2$ (1) $v = 12 \text{ ms}^{-1}$ (1)	3	
6	(a)	$E_p = m g h$ (1) $= 90 \times 10 \times 3$ (1) $= 2\,700 \text{ J}$ (1)	3	
	(b)	$E_k = \frac{1}{2} m v^2$ (1) $= \frac{1}{2} \times 90 \times 82$ (1) $= 2\,880 \text{ J}$ (1)	3	
	(c)	Extra energy has been supplied (1) by (the work done) pedalling (1)	2	

ELECTRIC CHARGE CARRIERS AND ELECTRIC FIELDS				
1		dc – electrons* flow around a circuit in one direction only (1) ac – electrons’* direction changes/reverses after a set time (1) *Accept ‘current’	2	
2		E	1	
3		D	1	
4		D	1	
5		$Q = It$ (1) $I = 1650/0.15$ (1) $= 1.1 \times 10^4 \text{ A}$ (1)	3	
6		D (1)	1	
7		C (1)	1	

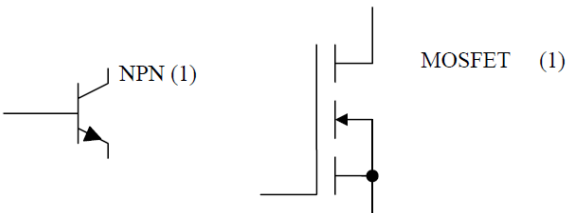
8		in d.c. electrons/charges move in one direction only (1) in a.c. direction of movement of electrons/charges continually reverses (1)	2	
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POTENTIAL DIFFERENCE (VOLTAGE)				
1		A (1)	1	
2		C (1)	1	

OHM'S LAW				
1		B	1	
2	(a)	$R_{\text{tot}} = 15 + 25 = 40 \, \Omega$ (1)  $V = IR$ (1) $20 = I \times 40$ (1) $I = 0.5 \, \text{A}$ (1)	4	
	(b)	$V = IR$ (1) $= 0.5 \times 15$ (1) $= 7.5 \, \text{V}$ (1)	3	
	(c)		2	
3	(a)	$I = 0.075 \, \text{A}$ (1) $V = IR$ (1) $4.2 = 0.075 \times R$ (1) $R = 56 \, \Omega$ (1)	4	
	(b)	stays the same (1) $\frac{1.3}{0.023} = 56.5$ $\frac{3.6}{0.064} = 56.25$ (1) or as the voltage increases the current increases by the same ratio or because it's a straight line through the origin	2	

PRACTICAL ELECTRICAL AND ELECTRONIC CIRCUITS				
1	(a)	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} \quad (1)$ $= \frac{1}{4} + \frac{1}{2} \quad (1)$ $\therefore R_T = 1.3 \Omega \quad (1)$	3	Accept 1 $\Omega$ , 1.33 $\Omega$ , 1.333 $\Omega$
	(b)	$R_T = R_1 + R_2 \quad (1)$ $= 1.3 + 6 \quad (1)$ $= 7.3 \Omega \quad (1)$	3	Consistent with (a) (1) <b>2</b> Accept 7.3 $\Omega$ , 7.33 $\Omega$ , 7.333 $\Omega$
	(c)	(Voltage across 2 $\Omega$ resistor = Voltage across 4 $\Omega$ resistor) $V = IR \quad (1)$ $= 0.1 \times 4 \text{ (or } 0.2 \times 2) \quad (1)$ $= 0.4 \text{ V} \quad (1)$	3	(2) max, if divide final answer by 2
2		E (1)	1	
3		A (1)	1	
4		D (1)	1	
5		A (1)	1	
6	(a)	Transistor (switch)	1	Ignore any prefix (eg bipolar, NPN, PNP)
	(b)	<ul style="list-style-type: none"> <li>(As temp increases,) input voltage to transistor increases</li> <li>(above 0.7V) switching transistor on</li> <li>Current in the (relay) coil (producing magnetic field).</li> <li>(Relay) switch closes / activates, (completing the bell circuit/ operating the bell).</li> </ul>	2	First bullet point may refer to voltage (output) from thermocouple or amplifier increasing but do not accept 'voltage' alone. Do not accept: 'transistor is saturated'
	(c)	$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} \quad (1)$ $\frac{1}{R_t} = \frac{1}{16} + \frac{1}{16} \quad (1)$ $R_t = 8 \Omega \quad (1)$	3	If wrong equation used eg $R_t = \frac{1}{R_1} + \frac{1}{R_2}$ then zero marks  Accept <i>imprecise</i> working towards a final answer $\frac{1}{R_t} = \frac{1}{16} + \frac{1}{16} = 8 \Omega$  Accept Deduct (1) for wrong/missing unit Can be answered by applying product over sum method



				Can be answered using 'identical value' parallel resistors method: $R = \frac{\text{value for single resistor}}{\text{total no. of Rs in parallel}}$
7		A (1)	1	
8		A (1)	1	
9		C (1)	1	
10		C (1)	1	
11		B (1)	1	
12		B (1)	1	
13		D (1)	1	
14		D (1)	1	
15	(a)		2	
	(b)	(electronic) switch	1	
	(c)	voltage across $5.5 \text{ k}\Omega$ resistor $= 9 - 2.4$ $= 6.6 \text{ V}$ (1)  $\frac{V_1}{V_2} = \frac{R_1}{R_2}$ (1) $\frac{2.4}{6.6} = \frac{R_1}{5500}$ (1) $R_1 = 2000\Omega$ (1)  OR  voltage across $5.5 \text{ k}\Omega$ resistor $= 9 - 2.4 = 6.6 \text{ V}$  $V = IR$ $6.6 = I \times 5500$ $I = 0.0012\text{A}$  $V = IR$ $2.4 = 0.0012 \times R$ $R = 2000\Omega$	4	
16		D (1)	1	
17	(a)	Thermistor (1)	1	
	(b)	as temperature drops, voltage across thermistor rises or resistance of thermistor rises (1) when voltage goes above certain level MOSFET switches on (1)	3	

		relay switch closes (and heater circuit is completed) (1)		
	(c)	to set the temperature at which the heater is switched on (1)	1	

ELECTRICAL POWER				
1		D	1	
2		A	1	
3		$P = I^2 R \quad (1)$ $= (200 \times 10^{-3})^2 \times 20 \quad (1)$ $= 0.8 \text{ W} \quad (1)$	3	deduct (1) for wrong/missing unit  Watch for unit conversion errors – penalise unit error only once
4	(a)	Use Ohm's Law twice. Once to calculate the current, then once to find $V_R$ .  $V = I R \quad (1) \text{ for both equations}$ $0.36 = I \times 2000 \quad (1) \text{ for both substitutions}$ $I = 0.00018 \text{ (A)}$  $V = I R$ $= 0.00018 \times 4800$ $= 8.64 \text{ V} \quad (1) \text{ for final answer}$	3	$\frac{V_1}{V_2} = \frac{R_1}{R_2} \quad (1)$ $\frac{V_1}{0.36} = \frac{48000}{2000} \quad (1)$ $V_2 = 8.64 \text{ V} \quad (1)$
	(b)	$P = \frac{V^2}{R} \quad (1)$ $3 = \frac{V^2}{48} \quad (1)$ $V^2 = 144$ $V = 12 \text{ V} \quad (1)$	3	Do NOT accept $V^2 = 144 = 12\text{V}$ (max 1 mark)
5		Method 1 $t = 1/250 = 0.004\text{(s)} \quad (1)$  $E = P t \quad (1)$ $60 \times 10^{-3} = P \times 0.004 \quad (1)$ $P = 15 \text{ W} \quad (1)$  Method 2 $E_{\text{Total}} = 250 \times 60 \times 10^{-3} \text{ (J)} \quad (1)$  $E = P t \quad (1)$ $15 = P \times 1 \quad (1)$ $P = 15 \text{ W} \quad (1)$	4	If correct time correctly calculated or stated award (1) mark (this may appear anywhere in the answer). • If time is stated or calculated wrongly and no calculation shown then (1) mark maximum for the power equation. • If calculation for the time / energy is shown and calculation contains an arithmetic error then deduct (1) mark
6		C	1	
7		B	1	
8		D	1	
9		$R = V^2/P \quad (1)$ $V = 230\text{V} \quad (1)$	3	Sf range: 2000 2100 2120

		$= 230^2/25 \quad (1)$ $= 2116 \, \Omega \quad (1)$		
<b>10</b>		$P = I^2 R \quad (1)$ $2 = I^2 \times 50 \quad (1)$ $I^2 = 0.04$ $I = 0.2 \, A \quad (1)$	3	

SPECIFIC HEAT CAPACITY				
1		$c = 4180 \text{ (J Kg}^{-1} \text{ C}^{-1}\text{)}$ (1) $E_h = c m \Delta T$ (1) $= 4180 \times 1.6 \times 80$ (1) $= 535040 \text{ J}$ (1)	4	(1) data mark for correct selection of <b>c</b> from 'Specific heat capacity of materials' table.  <b>If any other value from this table</b> is used, then lose data mark but can still get (3) marks max if rest of calculation is correctly executed using this value.  <b>If any value of c used not from this table</b> (including 4200) then only (1) max possible for correct selection of relationship.  No s.f. issue (exact answer)
2		$E_h = cm\Delta T$ (1) $= 4320 \times 82 \times 125$ (1) $= 44\,280\,000 \text{ J}$ (1)	3	Must use value for c given in question, otherwise (1) mark max for equation sig. fig. range 1–4 40 000 000    44 000 000 44 300 000    44 280 000
3	(a)	$(33-21) = 12 \text{ }^\circ\text{C}$	1	
	(i)			
	(ii)	$(120,000-12,000) = 108,000 \text{ J}$	1	
	(iii)	$E_h = cm\Delta T$ (1) $108,000 = c \times 2.0 \times 12$ (1) $c = 4,500 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$ (1)	3	Must be consistent with parts (i) + (ii)
	(b)	Measured value of $\square\square$ too large OR $\Delta T$ too small		
	(i)	(1) Heat lost to surroundings (or similar) * OR water not evenly heated (or similar) † (1)	2	*to air, from water, from equipment etc † or immersion heater not fully immersed Explanation must be offered
	(ii)	Insulate beaker <b>OR</b> Put lid on beaker <b>OR</b> Stir water <b>OR</b> Fully immerse heater	1	
	(c)	$E = P t$ (1) $108,000 = P \times (5 \times 60)$ (1) $P = 360 \text{ W}$ (1)	3	If no conversions answer is 21,600. Also accept 22,000, Max (2) must be consistent with (a) (ii) or wrong physics
4		D	1	

5	(a)	$E_h = cm\Delta T$ (1) $c = \frac{2.59 \times 10^7}{60 \times [(307 - (-173))]}$ (1) $= 899 \text{ J/kg}^\circ\text{C}$ (1)	3	
	(b)	$P = E/t$ (1) $t = 2.50 \times 10^7 / 1440$ (1) $= 18000 \text{ s}$ (1)	3	
	(c)	$288000 / 1440$ (1) $= 200 \text{ (rocks)}$ (1)	2	
6	(a)	$E_H = c m \Delta T$ (1) $= 2100 \times 0.6 \times 36$ (1) $= 45360 \text{ J}$ (1)	3	
	(b)	$E_H = I m$ (1) $= 2.34 \times 10^5 \times 0.6$ (1) $= 140\,400 \text{ J}$ (3)	3	
	(c) (i)	$\text{total } E_H = 45\,360 + 140\,400$ $= 185\,760 \text{ J}$ (1)  $E = P t$ (1) $185\,760 = 120 t$ (1) $t = 1548 \text{ s}$ (1)	4	
	(c) (ii)	No heat (energy) enters the ice cream (1)	1	
7	(a)	$E_H = c m \Delta T$ (1) $= 4180 \times 15 \times 6$ (1) $E_H = 376200 \text{ J}$ (1)	3	
	(b)	$E_H = c m \Delta T$ (1) $376200 = 480 \times 0.75 \times \Delta T$ (1) $\Delta T = 1045 \text{ (}^\circ\text{C)}$ (1) initial temperature of iron: $= 1045 + 23$ $= 1068 \text{ }^\circ\text{C}$ (1)	4	
	(c)	all heat energy retained within system OR no heat lost to surroundings (1) OR no steam created	1	
	(d)	greater (1)  value of c less OR less heat required per degree temperature rise OR greater temperature rise for same energy input (1) Note: first mark only available if explanation attempted		
8	(a)	$E_H = c m \Delta T$ (1) $E_H = 4180 \times 10 \times 80$ (1) $E_H = 3.34 \times 106 \text{ J}$ (1)	3	
	(b)	$E = P t$ (1) $3.34 \times 106 = 2.5 \times 103 \times t$ (1) $t = 1340 \text{ s}$ (1)	3	

	(c)	not all $E_H$ used to heat water OR $E_H$ lost to surroundings (1)	1	
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GAS LAWS AND THE KINETIC MODEL										
1		C (1)	1							
2		B (1)	1							
3		C (1)	1							
4		A (1)	1							
5		A (1)	1							
6		D (1)	1							
7	(a)	$P = F/A$ (1) $1.01 \times 10^5 = 262/A$ (1) $A = 2.59 \times 10^{-3} \text{ m}^2$ (1)	3							
	(b)	Volume increases/expands/gets bigger because P decreases $P \propto 1/V$ $PV = \text{const.}$ (1)	1	Look for this first						
8	(a)	$P_1 V_1 = P_2 V_2$ (1) $1.01 \times 10^5 \times 200 = P_2 \times 250$ (1) $P_2 = 8.1 \times 10^4 \text{ Pa}$ (1)	3	Accept: $P_2 = 8, 8.1, 8.08, 8.080 \times 10^4 \text{ Pa}$ OR 80 000, 81 000, 80 800 Pa						
	(b)	Number of collisions on walls of jar is less frequent/less often (1)  Average force (on walls) decreases (1)  Pressure on walls of jar decreases (1)	4	Must have atoms/molecules/particles colliding with the (container) walls before any marks can be given For ‘particles’ accept ‘molecules’ Must be frequency, not just “less collisions” Any mention of Ek or speed of particles changing – max ½ mark						
9	(a)	<table border="1"><tr><td>P/T</td><td>347</td><td>347</td><td>346</td><td>348</td><td>348</td></tr></table> (1) for all data Pressure and temperature are directly proportional when T is in Kelvin. OR $P/T = 347$ or “constant” (1)	P/T	347	347	346	348	348	2	
	P/T	347	347	346	348	348				
	(b)	As temperature increases, Ek of gas molecules/particles increases (1) (or molecules travel faster)  and hit/collide with the walls of the container more often/frequently OR <b>with greater force</b> (1)  pressure increases (1)	3	Must be Ek, not just "energy".  Must have atoms/molecules/particles colliding with the (container) walls somewhere in the answer before any of last 2 marks can be awarded						
		To ensure all the gas in the flask is heated evenly								



		OR all the gas is at the same temperature (1)	3	
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<b>10</b>	(a) (i)	$P \times V = 2000$ 1995 2002 2001 (1) $P \times V = \text{constant}$ (1) or $P \times V = 2000$ or $P_1V_1 = P_2V_2$ or $P = k/V$	2	All 4 values needed
	(a) (ii)	Gas molecules collide with walls of container more often (1) so (average) force increases (1) pressure increases (1)	3	Must have atoms/molecules/particles colliding with the (container) walls somewhere in the answer before any marks can be awarded pressure constant or decrease gets 0 molecules increasing or 'harder collisions' is WP so gets zero
	(b)	(As diver ascends) pressure decreases (1) volume of air in lungs will increase (1) (or pressure difference increases) so lungs may become damaged (1)	3	
<b>11</b>		$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ (1) $\frac{2.8 \times 10^6}{(19 + 273)} = \frac{P_2}{(5 + 273)}$ (1) $P_2 = 2.68 \times 10^6 \text{ Pa}$ (1)	3	

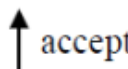
VARIOUS				
1	(a)	$I = \frac{P}{V}$ $= \frac{60}{230}$ $= 0.26 \text{ A}$	(1) (1) (1)	3 Sig. fig. Range: 0.3, 0.26, 0.261
	(b) (i)	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{1}{R_T} = \frac{1}{46} + \frac{1}{92}$ $R_T = 30.67 \Omega$	(1) (1) (1)	3 OR $R_T = \frac{R_1 R_2}{R_1 + R_2}$ $= \frac{46 \times 92}{46 + 92}$ $R_T = 30.67 \Omega$ If wrong equation used eg $R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$ then zero marks Accept <i>imprecise</i> working towards a final answer. $\frac{1}{R_T} = \frac{1}{46} + \frac{1}{92} = 30.67 \Omega$ <p style="text-align: center;"><math>\uparrow</math> <i>accept</i></p> Sig. fig. Range: 30, 31, 30.7, 30.67 If answer left as $30 \frac{2}{3}$ then (-1) (sig fig error) If intermediate rounding of $1/46$ and $1/92$ then deduct (1) for arith error.

(ii)	$P = \frac{V^2}{R} \quad (1)$ $= \frac{230^2}{30 \cdot 67} \quad (1)$ $= 1725 \text{ W} \quad (1)$ <p>Or calculate individual power of each heating element and add together</p>	3	<p>Must use value for <math>R_T</math> from 3(b)(i) or fresh start with <b>correct</b> value. Alternative solution:</p> $I = \frac{V}{R}$ $= \frac{230}{30 \cdot 67}$ $= 7 \cdot 5 \text{ (A)}$ <p>THEN</p> $P = IV$ $= 7 \cdot 5 \times 230$ $= 1725 \text{ W (1)}$ <p>OR</p> $P = I^2 R$ $= 7 \cdot 5^2 \times 30 \cdot 67$ $= 1725 \text{ W}$ <p>Award (1) for both equations Award (1) for all substitutions Award (1) for final answer</p> <p><math>P = I^2 R</math> Award (1) mark for <math>= 7 \cdot 5^2 \times 30 \cdot 67</math> final answer <math>= 1725 \text{ W}</math></p> <p>If <math>R = 138 \Omega</math> from b(i) then <math>P = 383 \text{ W}</math></p> <p>Sig figs depend on candidates answer to (b) part (i)</p>
(iii) (A)	S3 (only)	1	
(iii) (B)	Greatest value of resistance/ lowest current/lowest power	1	<p>Accept: ‘heating element with greatest resistance has lowest power output/rating “because it has the biggest/largest resistance”</p> <p>DO NOT accept “bigger resistor”</p>

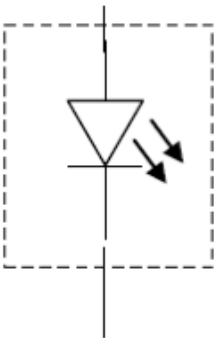
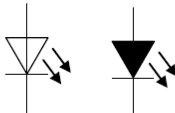
				Can only get second mark if S3 selected.
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2	(a)	$I = \frac{V}{R}$ $= \frac{12}{64000}$ $= 1.875 \times 10^{-4} \text{ (A)}$ <p>THEN</p> $V = IR$ $= 1.875 \times 10^{-4} \times 4000$ $= 0.75 \text{ V}$ <p>Award (1) for both formulae</p> <p>Award (1) mark for all substitutions correct</p> <p>Award (1) mark for final answer</p>	3	<p>Alternatives:</p> $V_1 = \frac{R_1}{R_1 + R_2} \times V_s$ $= \frac{4000}{4000 + 60000} \times 12$ $= 0.75 \text{ V}$ <p>OR</p> $\frac{V_1}{V_2} = \frac{R_1}{R_2}$ $\frac{12}{V_2} = \frac{64000}{4000} \text{ (1)}$ $V_2 = 0.75 \text{ V (1)}$ <p>Only accept this method if the substitutions are for: the supply voltage, the <b>total</b> resistance, and the resistance of the LDR. Award zero marks if this relationship is stated alone or implied by any other substitutions</p> <p>eg <math>\frac{12}{V_2} = \frac{60000}{4000}</math></p>
	(b)	Transistor (switch)	1	<p>Ignore any reference to pnp or npn</p> <p>NOT:</p> <ul style="list-style-type: none"> <li>• Phototransistor</li> <li>• MOSFET transistor</li> <li>• Switch alone</li> </ul>
	(c)	<ul style="list-style-type: none"> <li>• R of LDR increases</li> <li>• V across LDR increases (above 0.7V)</li> <li>• Transistor switches ON</li> <li>• Relay coil is energised (which closes the relay switch and activates the motor)</li> </ul>	2	<p>All 4 bullet points needed for (2)</p> <p>Must clearly identify:</p> <ul style="list-style-type: none"> <li>• the resistance of LDR increasing</li> <li>• the voltage across LDR increasing</li> <li>• transistor on</li> </ul>

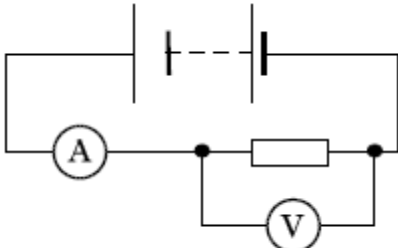
				<ul style="list-style-type: none"> <li>• relay coil operates/is switched on/</li> <li>• activated/magnetised</li> </ul>
3	(a)	To reduce current in LED <b>OR</b> To reduce voltage across LED <b>OR</b> To reduce power to LED	1	
	(b)	$V = 6 - 2 = 4 \text{ V}$ (1)  $V = IR$ (1) $4 = 0.1 \times R$ (1) $R = 40 \Omega$ (1)	4	
	(c)	<div style="display: flex; justify-content: space-between;"> <div> <math>P = I^2 R</math> (1)  <math>= (0.1)^2 \times 40</math> (1)  <math>= 0.4 \text{ W}</math> (1) </div> <div> <math>P = V^2 / R</math>  <math>= 4^2 / 40</math>  <math>= 0.4 \text{ W}</math> </div> </div> $P = IV$ (1) $= 0.1 \times 4$ (1) $= 0.4 \text{ W}$ (1)	3	Must be consistent with (b)

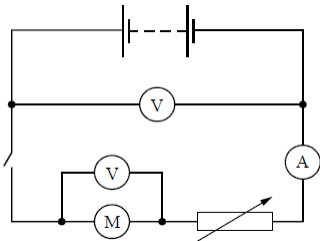
4	(a)	$P = I V$ (1)			
	(i)	$36 = I \times 12$ (1) $I = 3 \text{ A}$ (1)	3		Deduct (1) for wrong/missing unit
	(ii)	$48 = 12 + 12 + V_R$ $V_R = 24 \text{ V}$ (1)	1		Deduct (1) for wrong/missing unit
	(iii)	$V = I R$ (1) $24 = 3 \times R$ (1) $R = 8 \Omega$ (1)	3		Must use answers from 3 (a)(i) and (ii) or correct answers Deduct (1) for wrong/missing unit
	(b)				
	(i)	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$ (1) $\frac{1}{R_T} = \frac{1}{6} + \frac{1}{4} + \frac{1}{4}$ (1) $\frac{1}{R_T} = 0.17 + 0.25 + 0.25$ $R_T = 1.5 \Omega$ (1)	3		If wrong equation used eg $R_T = \frac{1}{R_1} + \frac{1}{R_2}$ then zero marks  Accept <i>imprecise</i> working towards a final answer $\frac{1}{R_T} = \frac{1}{6} + \frac{1}{4} + \frac{1}{4} = 1.5 \Omega$   deduct (1) for wrong/missing unit Can be answered by applying product over sum method. If applied twice.  Accept $3/2$ and $1 \frac{1}{2} \Omega$ as final answer.
	(ii)				
	A	The reading decreases/gets smaller/reduces	1		Any clear statement that the reading decreases
	B	The resistance increases (so the current decreases)	1		Explanation must link current <b>decrease</b> with increase of resistance

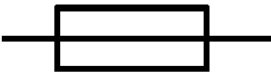


5	(a)		1	<p>accept</p>  <p>Must have connecting wires at both ends.</p> <p>accept:</p> <ul style="list-style-type: none"> <li>no line through middle</li> <li>arrows could be either side</li> <li>accept black (fill) triangle</li> </ul>
	(b)	Protect the LED OR prevent damage to the LED OR limits the current OR reduces voltage across LED	1	<p>(1) for a correct answer.</p> <p>Not:</p> <ul style="list-style-type: none"> <li>'voltage through/current across LED.'</li> <li>To reduce voltage alone</li> <li>To stop LED 'blowing'.</li> <li>To reduce charge/power to LED</li> <li>To prevent LED overheating</li> </ul>
	(c)	$V_R = 6 - 1.2 = 4.8 \text{ V} \quad (1)$ $V = IR \quad (1)$ $4.8 = 15 \times 10^{-3} \times R \quad (1)$ $R = 320 \text{ } \Omega \quad (1)$	4	<p>If error can be seen in subtraction to get <math>V_R</math> then can still get (3) marks</p> <p><b>If no subtraction</b> and 6 V or 1.2 V used in calculation for R then (1) MAX for equation.</p> <p>Deduct (1) for wrong/missing unit</p> <p>This can also be answered using voltage divider method.</p>
6	(a)	$E = Pt \quad (1)$ $= 1500 \times 35 \quad (1)$ $= 52\,500 \text{ J} \quad (1)$	3	<p>Deduct (1) for wrong/missing unit</p> <p>Watch for unit conversion errors – penalise unit error only once</p>
	(b)	$E = cm\Delta T \quad (1)$ $52\,500 = 902 \times m \times (200 - 24) \quad (1)$ $m = 0.33 \text{ kg} \quad (1)$	1	<p>Must use value for Energy from 6(a) OR correct value.</p> <p>Must use value for c given in question or else (1) max for eqn</p> <p>Deduct (1) for wrong/missing unit</p> <p>Sig fig range: 0.3, 0.33, 0.331, 0.3307.</p>
	(c)	<p>Heat is</p> <ul style="list-style-type: none"> <li>Lost OR</li> <li>Radiated OR</li> <li>escapes OR</li> </ul> <p>from the sole plate</p>	1	<p>Accept:</p> <ul style="list-style-type: none"> <li>Heat is lost/radiated/ escapes to the surroundings</li> <li>Some of the heat (energy) is used to heat other parts of the iron</li> </ul> <p>The explanation should indicate that heat is lost from/to... eg</p>

				<ul style="list-style-type: none"> <li>• power rating of iron is incorrect</li> <li>• inaccurate temperature readings etc.</li> </ul>
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7	(a)	$E_p = m g h$ (1) $= 0.50 \times 9.8 \times 19.3$ (1) $= 95 \text{ J}$ (1)	3	
	(b)	$E_c = c m \Delta T$ (1) $95 = 386 \times 0.50 \times \Delta T$ (1) $\Delta T = 0.5 \text{ }^\circ\text{C}$ (1)	3	$E_h$ must be consistent with (a). If any other value of 'c' used, only (1) for formula.
	(c) (i)	Less than.	1	If 'less than' is on its own = 0 marks. 'Less than' plus wrong explanation = 1 mark.
	(ii)	Some heat is lost to surroundings/ or equivalent.	1	'Heat loss to' must be qualified. Qualified sound loss OK eg on hitting the ground
8	(a)		3	<b>Must draw battery, not single cell.</b>
	(b)	$V = IR$ (1) $5.7 = 0.60 \times R$ (1) $R = 9.5 \Omega$ (1)	3	
	(c) (i)	No	1	
	(ii)	In parallel the voltage is still the same/6V across each resistor so power is the same	1	
9	(a)	MOSFET	1	Transistor on its own = 0 Correct spelling required
	(b)	(Voltage) falls/decreases	1	Or equivalent Arrows not allowed

10	(a)		1	<p>Must have <b>all</b> labels correctly positioned .</p> <p>(1) or (0) only</p>
	(b)	$V_r = V_s - V_{\text{motor}}$ $= 24 = 18$ $= 6(\text{V}) \quad (1)$ $V_r = I R \quad (1)$ $6 = I \times 2.1 \quad (1)$ $I = 2.9 \text{ A} \quad (1)$	4	<p>If arithmetic error can be seen in subtraction to get <math>V_r</math> then deduct (1) mark. Candidate can still get next (3) marks.</p> <p><b>If no subtraction</b> and 24 V or 18 V used in calculation for V then (1) MAX for equation. Deduct (1) for wrong/missing unit</p> <p><math>V = I \times R</math> sig. fig. range: 1–4 3A, 2.9A, 2.86A, 2.857A</p>
	(c)	$Q = I \times t \quad (1)$ $= 3.2 \times (10 \times 60 \times 60) \quad (1)$ $= 115\,200 \text{ C} \quad (1)$	3	<p>Accept: 100000C, 120 000C, 115 000C, 115200C.</p> <p>If wrong or no conversion into seconds then deduct (1) mark.</p>
	(d)	<p>Accept</p> <ul style="list-style-type: none"> <li>• Change the polarity of the battery</li> <li>• Swap over the connections to the motor</li> <li>• Change <b>the direction</b> of the current</li> <li>• Reverse current</li> <li>• Swap battery terminals</li> </ul>	1	<p>Do not accept</p> <ul style="list-style-type: none"> <li>• “swap battery” alone.</li> <li>• Turn the battery around alone.</li> <li>• Swap the battery around alone.</li> <li>• Any answers relating to magnetic field (not relevant to this question)</li> </ul> <p>If &gt; one answer apply <math>\pm</math>rule.</p>
11	(a)	Parallel	1	Only answer ignore spelling
	(b)	$P = I V \quad (1)$ $300 = I \times 230 \quad (1)$ $I = 1.3 \text{ A} \quad (1)$ <p>OR</p> $P = I V \quad (1)$ $900 = I \times 230$ $I = 3.9 \text{ A}$ $\text{Current in one mat} = 3.9/3 \quad (1)$ $I = 1.3 \text{ A} \quad (1)$	3	<p>sig. fig. range: 1–3 1A 1.3A 1.30A</p>
	(c)	$P_{\text{total}} = 3 \times 300\text{W} = 900\text{W} \quad (1)$ $P = V^2 / R \quad (1)$ $900 = 230^2 / R \quad (1)$ $R = 59 \, \Omega \quad (1)$ <p>Or</p> $I_{\text{total}} = 3 \times 1.3 = 3.9 \text{ A} \quad (1)$		<p>sig. fig. 1–3 range: 60<math>\Omega</math> 59<math>\Omega</math> 58.8<math>\Omega</math></p> <p>sig. fig. 1–3</p>

		$P = I^2 R$ (1) $900 = 3.9^2 \times R$ (1) $R = 59 \Omega$ (1)	4	range: 60Ω, 59Ω, 59.2Ω
<b>12</b>	(a)	Lamp A	1	
	(i)			
	(ii)	It has the lowest resistance/highest current/greatest power	1	one of three
	(b)	$P = V^2/R$ (1) $= 24^2/2.5$ (1) $= 230 \text{ W}$ (1)	3	
	(c)		1	
	(d)	12 V	1	unit required
	(i)			
	(ii)	$1/R_p = 1/R_1 + 1/R_2$ (1) $= 1/8 + 1/24$ (1) $R_p = 6 \Omega$ (1)	3	
<b>13</b>	(e)	The motor speed will reduce	1	
	(i)			
	(ii)	The (combined) resistance (of the circuit) is now higher/current is lower. Voltage across motor is less Motor has less power	1	any one of four
	(a)	X = (NPN) transistor	1	0 marks for MOSFET or PNP transistor
	(i)			
	(ii)	To act as a switch	1	To turn on the buzzer 0 marks To operate the buzzer 0 marks
	(b)	Resistance of LDR reduces so voltage across LDR reduces Voltage across variable resistor/R increases When voltage across variable resistor/R reaches (0.7 V) transistor switches buzzer on.	3	Accept 'when voltage is high enough'
	(c)	80 units: resistance of LDR = 2500 (Ω) Total resistance = 2500 + 570 = 3070 (Ω) (1) ----- $I = V/R$ (1) = 5/3070 (1) = $1.63 \times 10^{-3} \text{ A}$ or 1.63 mA (1)	4	1.6 mA 1.63 mA 1.629 mA
	(d)	The variable resistor is to set the light level at which the transistor will switch on or to set the level at which the buzzer will sound	1	

