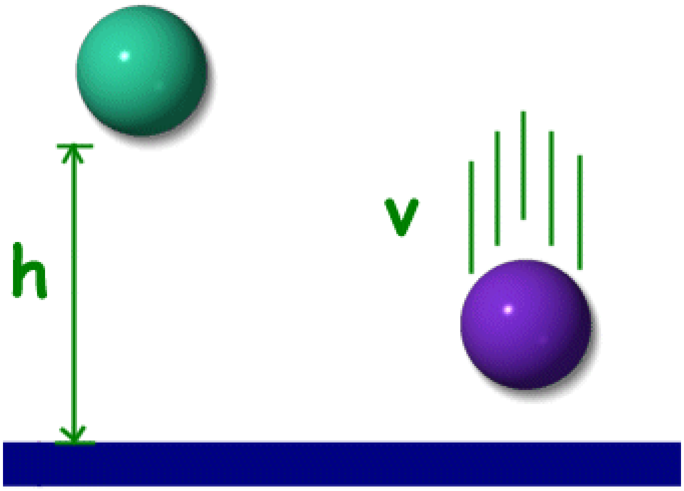
# NATIONAL 5 PHYSICS

# UNIT 3 — ENERGY & ELECTRICITY

## WRITTEN QUESTIONS

## 2007—2019

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## Circuits



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## Kinetic Theory

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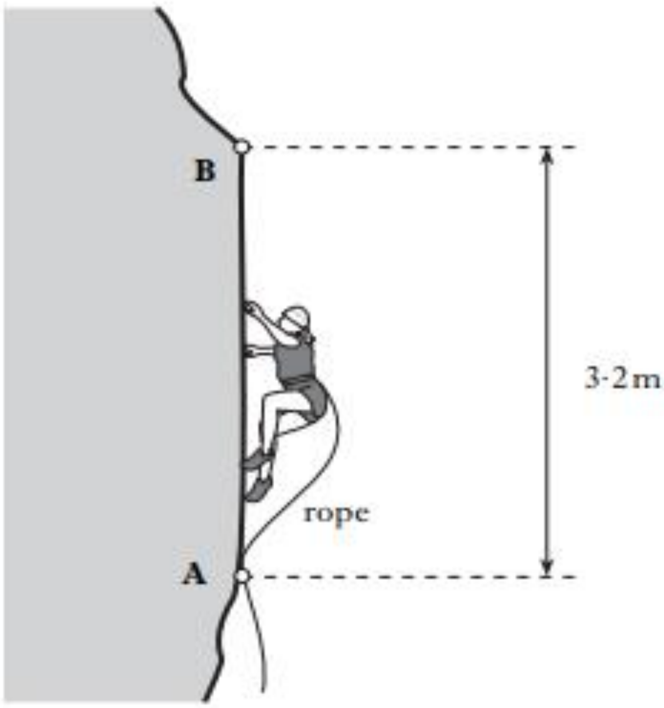
# Energy

Int 2 2007 Q 21 a(iii), b

**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)**

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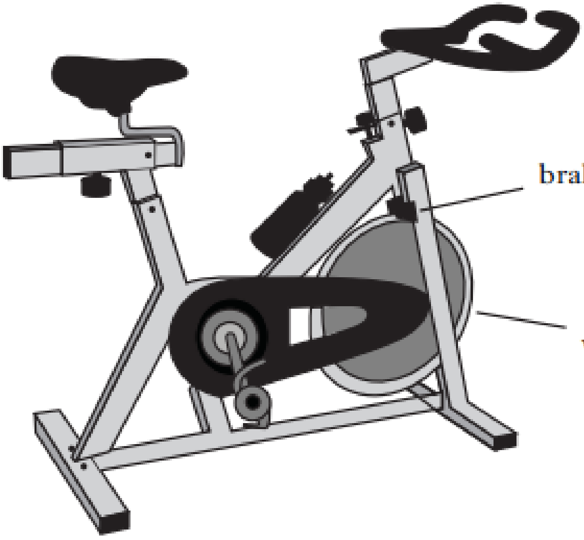
Int 2 2008 Q23 a

**23.** One type of exercise machine is shown below.




(*a*) A person using this machine pedals against friction forces applied to the wheel by the brake.

A friction force of 300 N is applied at the edge of the wheel, which has a circumference of 1·5 m.

(i) How much work is done by friction in one turn of the wheel? **2**

(ii) The person turns the wheel 500 times in 5 minutes.

Calculate the average power produced. **3**

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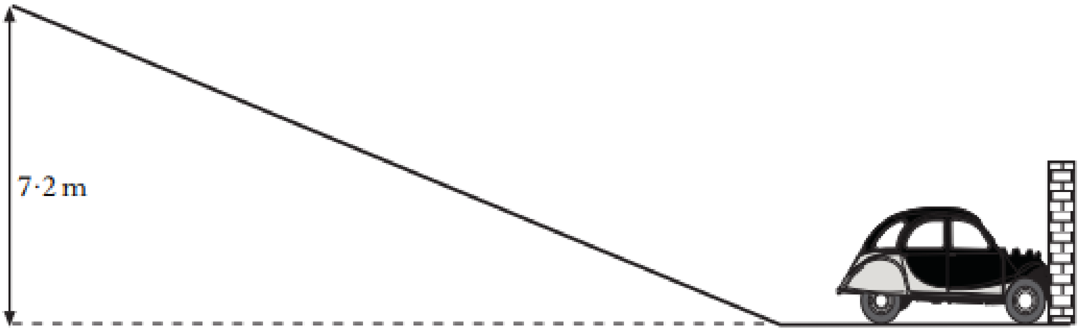
Int 2 2008 Q 24

**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**

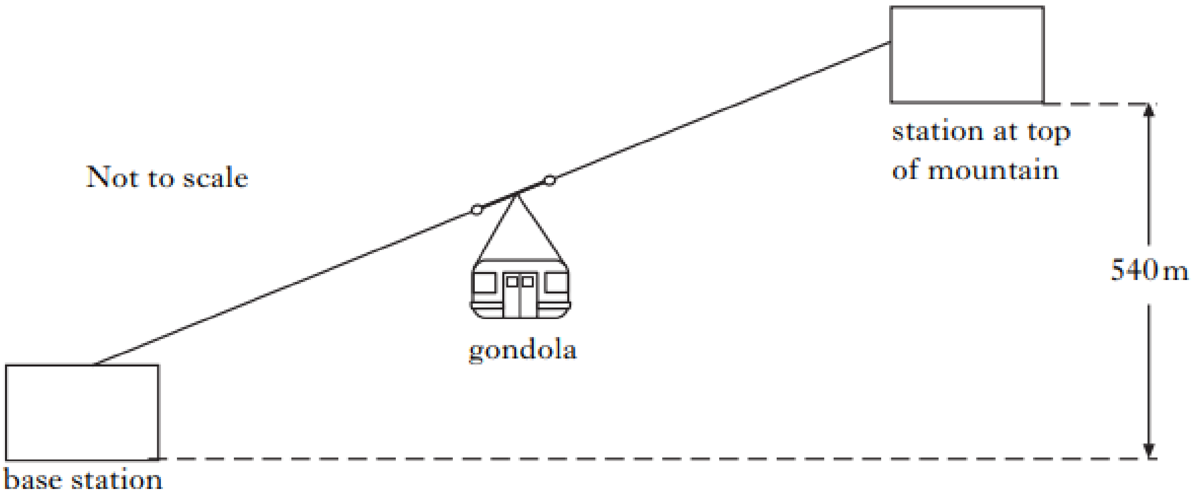
(*b*) (i) State the value of the kinetic energy of the car at the bottom of the slope, assuming no energy losses. **1**

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

**(5)**

Int 2 2009 Q21ab

**21.** A ski lift with a gondola of mass 2000 kg travels to a height of 540 m from the base station to a station at the top of the mountain.




(*a*) Calculate the gain in gravitational potential energy of the gondola. **2**

(*b*) During the journey, the kinetic energy of the gondola is 64 000 J.

Calculate the speed of the gondola. **2**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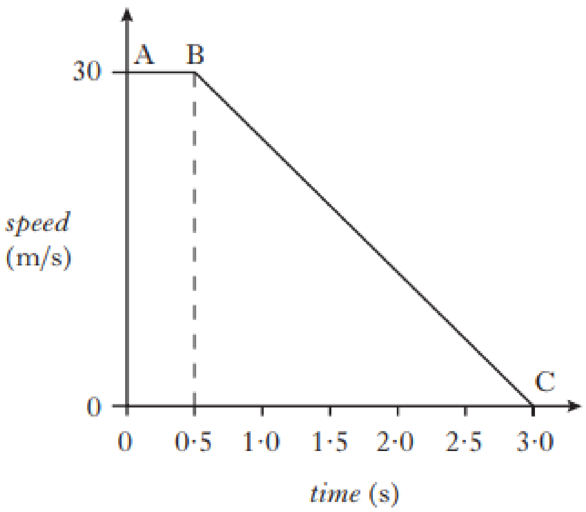
## Int 2 2012 22 b,c

**22.** A car of mass 700 kg travels along a motorway at a constant speed. The driver sees a traffic hold-up ahead and performs an emergency stop. A graph of the car's motion is shown, from the moment the driver sees the hold-up.



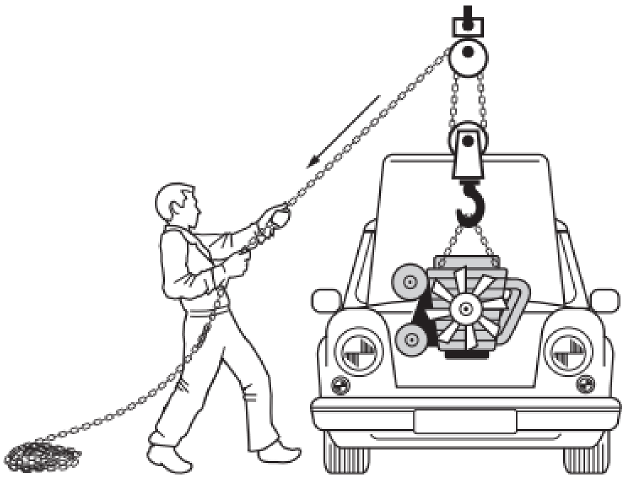

(*a*) Describe **and** explain the motion of the car between A and B. **2**

(*b*) Calculate the kinetic energy of the car at A. **2**

(*c*) State the work done in bringing the car to a halt between B and C. **1**

## Int 2 2013 Q 24 a,b

**24.** In a garage, a mechanic lifts an engine from a car using a pulley system.



(*a*) The mechanic pulls 4·5 m of chain with a constant force of 250 N.

Calculate the work done by the mechanic. **2**

(*b*) The engine has a mass of 144 kg and is raised 0·75 m.

Calculate the gravitational potential energy gained by the engine. **2**

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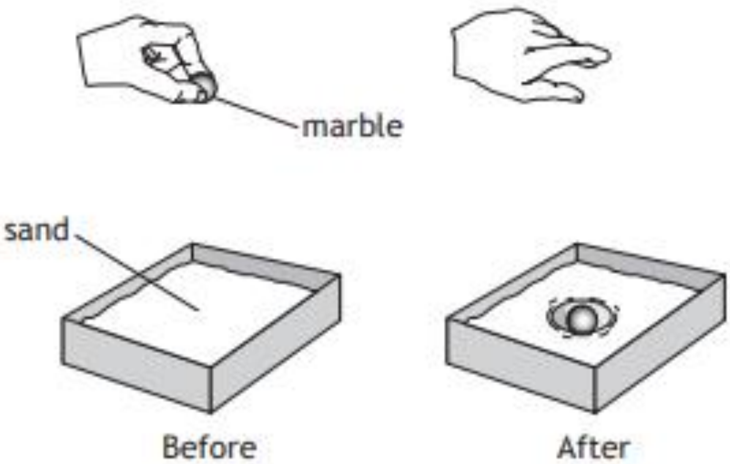
N5 2015 Q 11 a

11. Craters on the Moon are caused by meteors striking its surface.

MARK

A student investigates how a crater is formed by dropping a marble into a tray of sand.




(a) The marble has a mass of 0·040 kg.

(i) Calculate the loss in potential energy of the marble when it is dropped from a height of 0·50 m. 3

(ii) Describe the energy change that takes place as the marble hits the sand. 1

N5 2017 Q 11 c

(c) The tennis court has a retractable roof to allow play to continue in all weather conditions.

It requires 5·5 kJ of energy to move one section of the roof a distance of 25 m.

Calculate the average force acting on this section of the roof while it is being moved. 3

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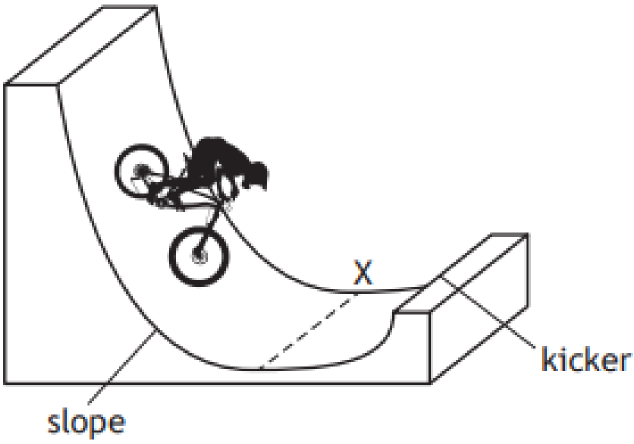
N5 2018 Q 3 a,b

3. During a BMX competition, a cyclist freewheels down a slope and up a 'kicker' to complete a vertical jump.




The cyclist and bike have a combined mass of 75 kg.

At point X the cyclist and bike have a speed of $8 \cdot 0\ m\ s^{-1}$.

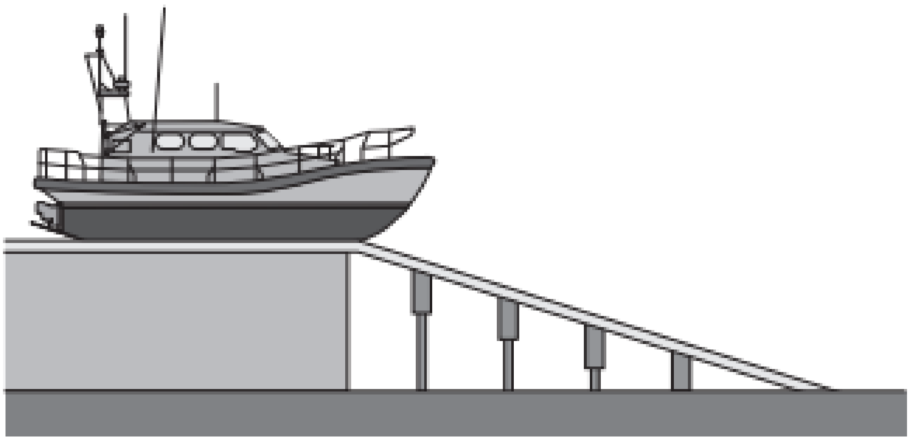
(a) Calculate the kinetic energy of the cyclist and bike at point X. **3**

(b) (i) Calculate the maximum height of the jump above point X. **3**

(ii) Explain why the actual height of the jump above point X would be less than the height calculated in (b) (i). **1**

N5 2019 Q 9 c

(c) The lifeboat has a mass of 25 000 kg. When it is launched, it loses $4 \cdot 5 \times 10^5$ J of gravitational potential energy before it enters the water.



(i) Calculate the maximum speed of the lifeboat as it enters the water. **3**

(ii) Explain why, in practice, the speed of the lifeboat as it enters the water is less than calculated in (c) (i). **1**

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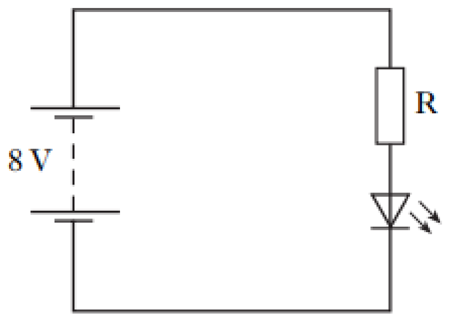
## Circuits

Int 2 2007 Q 25 b,c

(*b*) The laser gun operates from a 7·2 V rechargeable battery. The battery is charged from the mains and takes two hours to fully recharge. A current of 3 A is used in the charging circuit.

Calculate how much charge the battery stores when fully charged. **2**

(*c*) When the IR beam hits a sensor on the target jacket, the following circuit is completed and the LED lights. The LED has an operating voltage of 2 V and an operating current of 15 mA. The circuit has an 8 V supply.



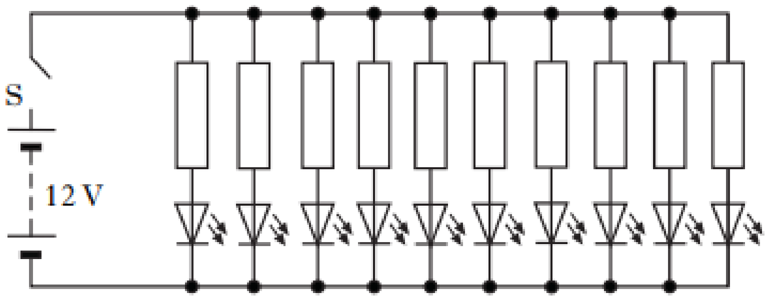

Calculate the value of resistor R. **3**

Int 2 2008 Q 28 a

*Marks*

**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**

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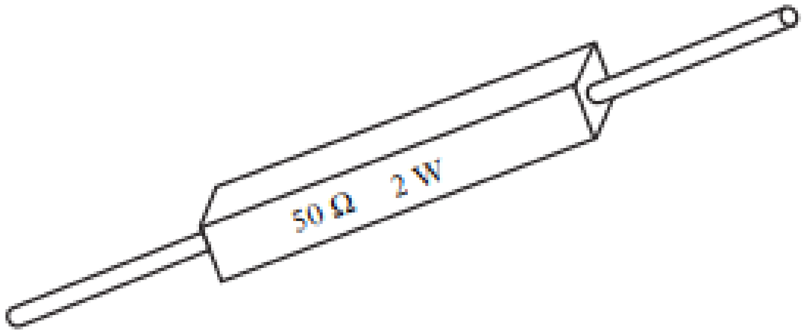
Int 2 2008 Q 25

*Marks*

**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.

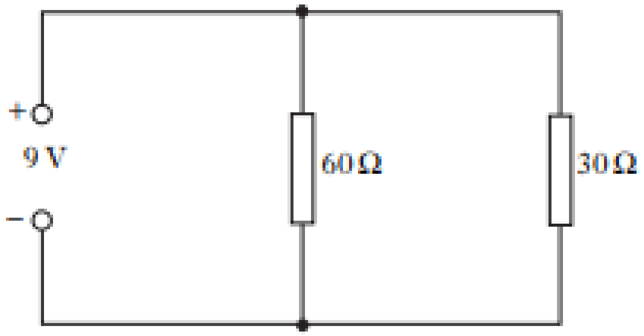



(*a*) A resistor is labelled 50 Ω, 2 W.

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**

Int 2 2009 Q 21 c

(*c*) The ski lift requires a motor which operates at 380 V to take the gondola up the mountain. The maximum power produced is 45·6 kW.

(i) Calculate the maximum current in the motor. **2**

(ii) Calculate the electrical energy used by the motor when it has been operating at its maximum power for a total time of 1 hour. **2**

**(8)**

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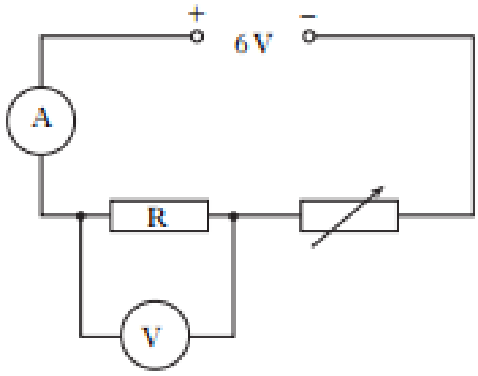
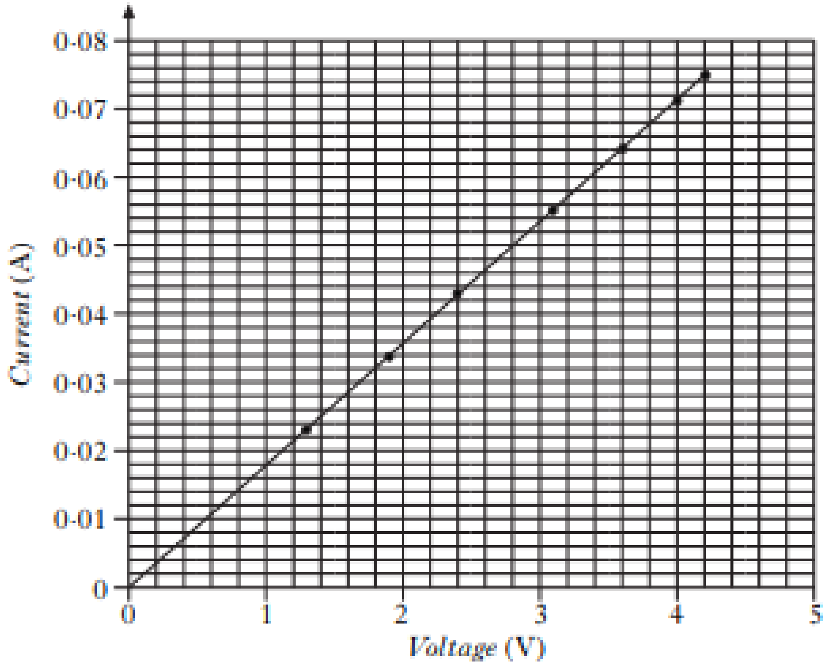
Int 2 2009 Q 25

*Marks*

**25.** 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*) (i) Calculate the value of the resistor R when the reading on the voltmeter is 4·2 V. **3**

(ii) 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**

(*b*) The student is given a task to combine two resistors from a pack containing one each of 33 Ω, 56 Ω, 82 Ω, 150 Ω, 270 Ω, 390 Ω.

Show by calculation which **two** resistors should be used to give:

(i) the largest combined resistance; **2**

(ii) the smallest combined resistance. **2**

**(9)**

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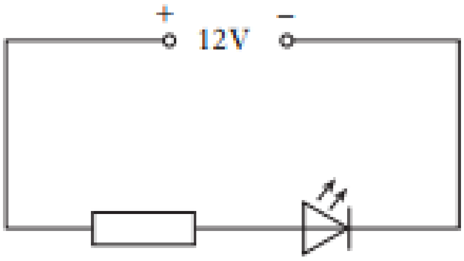
Int 2 2009 Q 28 d

(*d*) An LED system can be added so that it flashes at the same frequency as the beeps from the buzzer. The LED circuit is shown below.




(i) A resistor is connected in series with the LED.

State the purpose of the resistor. **1**

(ii) When lit, the LED has a voltage of 3·5 V across it and a current of 200 mA.

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

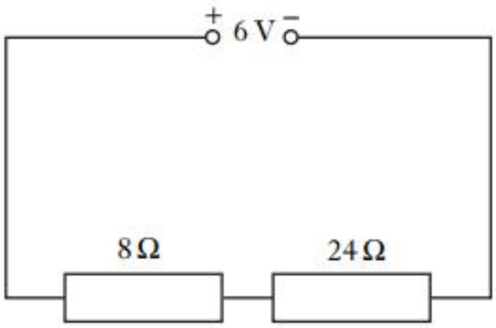
Int 2 2010 Q 22 c

(*c*) The motion of water droplets in the cloud causes flashes of lightning. One lightning flash transfers 1650 C of charge in 0·15 s.

Calculate the electric current produced by this flash. **2**

Int 2 2010 Q 24

**24.** A student sets up the following circuit.




(*a*) Calculate the current in the 8 Ω resistor. **3**

(*b*) Calculate the voltage across the 8 Ω resistor. **2**

(*c*) The 24 Ω resistor is replaced by one of **greater** resistance. How will this affect the voltage across the 8 Ω resistor?

Explain your answer. **2**

**(7)**

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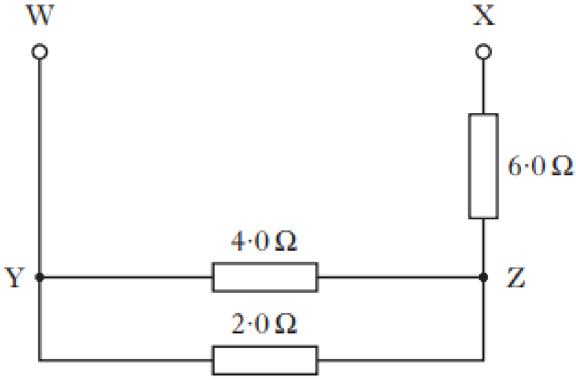
Int 2 2011 Q 25

**25.** Part of a circuit is shown below.




(*a*) Calculate the total resistance between points Y and Z. **2**

(*b*) Calculate the total resistance between points W and X. **2**

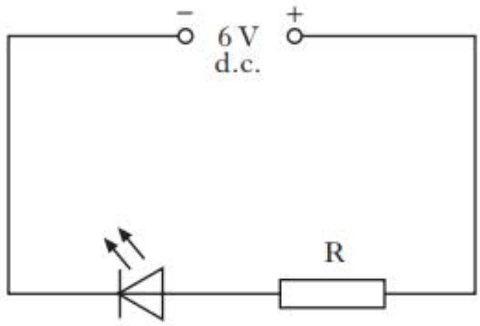
(*c*) Calculate the voltage across the 2·0 Ω resistor when the current in the 4·0 Ω resistor is 0·10 A. **2**

**(6)**

Int 2 2011 Q 27

**27.** 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*) What is the purpose of resistor R? **1**

(*b*) The LED is rated at 2 V, 100 mA. Calculate the resistance of resistor R. **3**

(*c*) Calculate the power developed by resistor R when the LED is working normally. **2**

**(6)**

Int 2 2011 Q 29 b

(*b*) The Sun produces a *solar wind* consisting of charged particles. In one particular part of the solar wind, a charge of 360 C passes a point in space in one minute. Calculate the current. **2**

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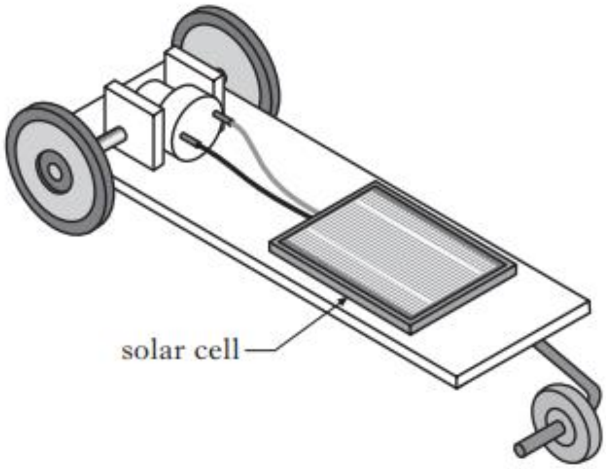
Int 2 2011 Q 28 a,b

**28.** A solar cell is tested for use in a buggy.




The solar cell produces a voltage of 0·5 V and a current of 0·4 mA.

(*a*) (i) Calculate the power produced by the solar cell. **2**

(ii) The buggy requires 4 mW to operate. Calculate the number of solar cells required to supply this power. **2**

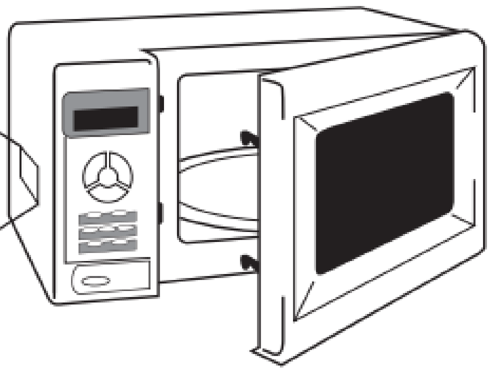
(*b*) State the energy change in a solar cell. **1**

Int 2 2013 Q 25 a,b

**25.** The rating plate on a microwave oven shows the following data.

**Rating Plate**

| | |
|---|---|
| Voltage | = 230 V a.c. |
| Input electrical power | = 1196 W |
| Output microwave power | = 700 W |
| Microwave frequency | = 2500 MHz |



(*a*) State what is meant by the term voltage. **1**

(*b*) (i) Calculate the input current. **2**

(ii) The microwave is used to heat a cup of milk for 1 minute 30 seconds. Calculate how much electrical charge passes through the flex in this time. **2**

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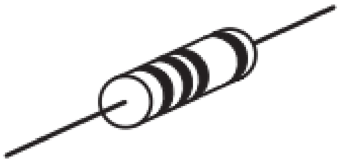
Int 2 2012 Q 24

**24.** A resistor is labelled: "10 Ω ± 10%, 3 W".



This means that the resistance value could actually be between 9 Ω and 11 Ω.

(*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 V and the current in the resistor as 0·60 A.

Use these values to calculate the resistance. **2**

(*c*) During this experiment, the resistor becomes very hot and gives off smoke.

Explain why this happens.

You **must** include a calculation as part of your answer. **3**

(*d*) The student states that **two** of these resistors would not have overheated if they were connected together in parallel with the battery.

Is the student correct?

Explain your answer. **2**

**(10)**

Int 2 2013 Q 26

**26.** 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 V, 2·5 Ω

**Lamp B**: rated 24·0 V, 5·4 Ω

(*a*) Which lamp gives a brighter light when operating at the correct voltage?

Explain your answer. **2**

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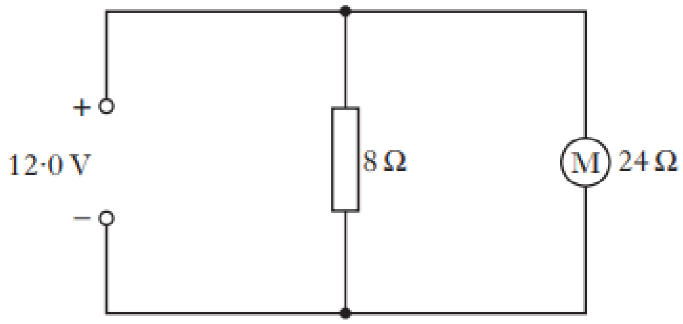
(*b*) Calculate the power developed by lamp A when it is operating normally. **2**

(*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**.

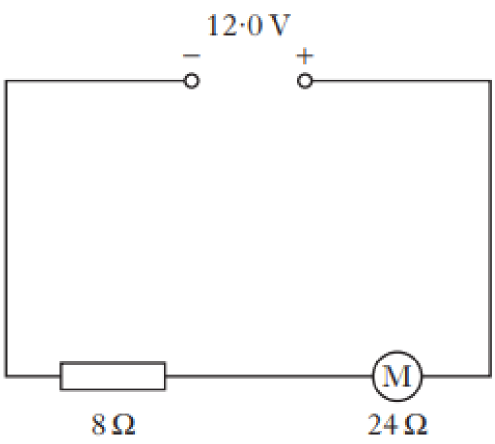



**Circuit 1**

(i) State the voltage across the motor. **1**

(ii) Calculate the combined resistance of the resistor and the motor. **2**

(*e*) The resistor and the motor are now connected in series, as shown in **Circuit 2**.




**Circuit 2**

State how this affects the speed of the motor compared to **Circuit 1**.

Explain your answer. **2**

**(10)**

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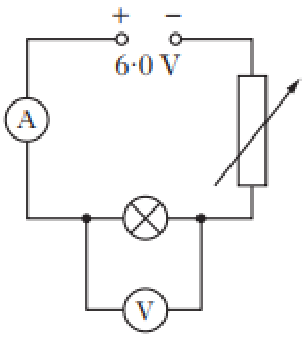
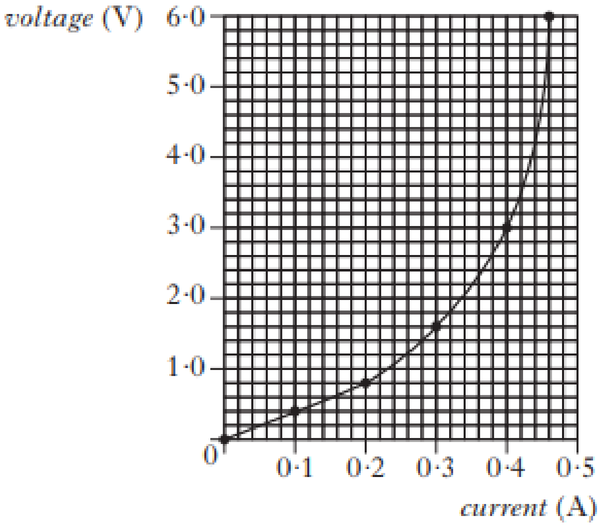
**24.** The circuit shown is used to investigate the relationship between voltage and current for a filament lamp.




(*a*) State the energy transformation in the filament lamp. **1**

(*b*) The variable resistor is altered and readings of current and voltage are taken. These values are plotted on the graph shown.




(i) Calculate the resistance of the filament lamp when the current is 0·4 A. **2**

(ii) What happens to the resistance of the filament lamp as the voltage across it increases?

You **must** justify your answer. **2**

(*c*) In many modern electronic systems LEDs are used instead of filament lamps.

(i) Using a 6·0 V supply, a 2·0 V LED and one other suitable component, draw a circuit that would allow the LED to light. **2**

(ii) A red LED emits light of wavelength $6{\cdot}0 \times 10^{-7}$ m.

Calculate the frequency of this light. **2**

(iii) Filament lamps and LEDs are examples of output devices. Name one other output device. **1**

**(10)**

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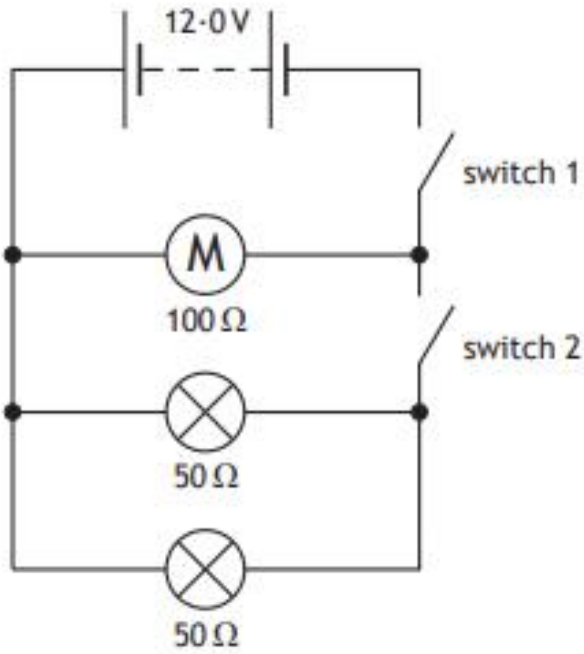
1. A toy car contains an electric circuit which consists of a 12·0 V battery, an electric motor and two lamps.

The circuit diagram is shown.




(a) Switch 1 is now closed.

Calculate the power dissipated in the motor when operating. **3**

(b) Switch 2 is now also closed.

(i) Calculate the total resistance of the motor and the two lamps. **3**

(ii) One of the lamps now develops a fault and stops working.

State the effect this has on the other lamp.

You **must** justify your answer. **2**

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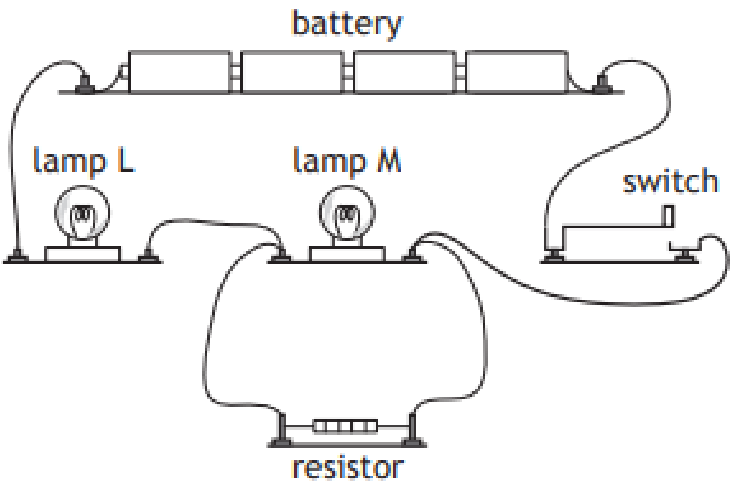
N5 2015 Q 1

1. A student sets up the following circuit using a battery, two lamps, a switch and a resistor.




(a) Draw a circuit diagram for this circuit using the correct symbols for the components. **3**

(b) Each lamp is rated 2·5 V, 0·50 A.

Calculate the resistance of one of the lamps when it is operating at the correct voltage. **3**

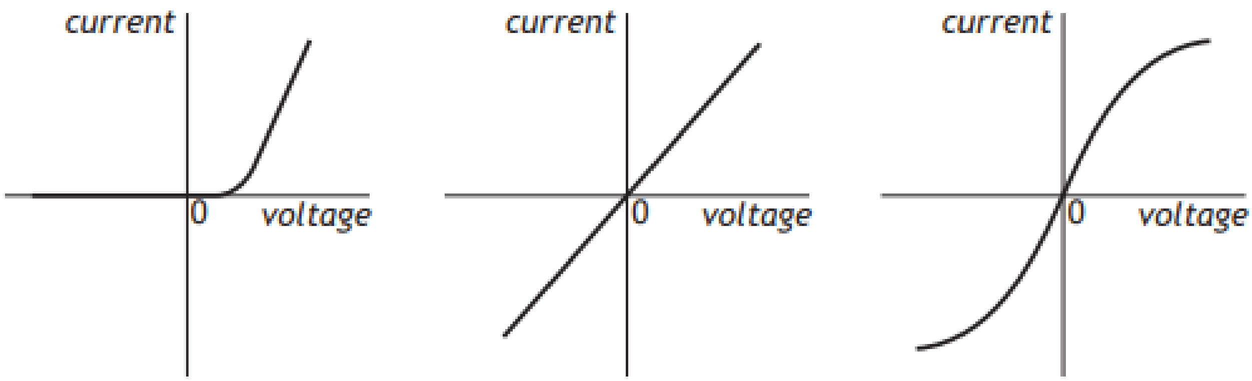
(c) When the switch is closed, will lamp L be brighter, dimmer or the same brightness as lamp M?

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

N5 2015 Q 2

2. (a) A student investigates the electrical properties of three different components; a lamp, an LED and a fixed resistor.

Current-voltage graphs produced from the student's results are shown.




Graph X Graph Y Graph Z

Explain which graph X, Y or Z is obtained from the student's results for the LED. **2**

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(b) One of the components is operated at 4·0 V with a current of 0·50 A for 60 seconds.

(i) Calculate the energy transferred to the component during this time. **4**

(ii) Calculate the charge which passes through this component during this time. **3**

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N5 2016 Q 1

1. Electrical storms occur throughout the world.

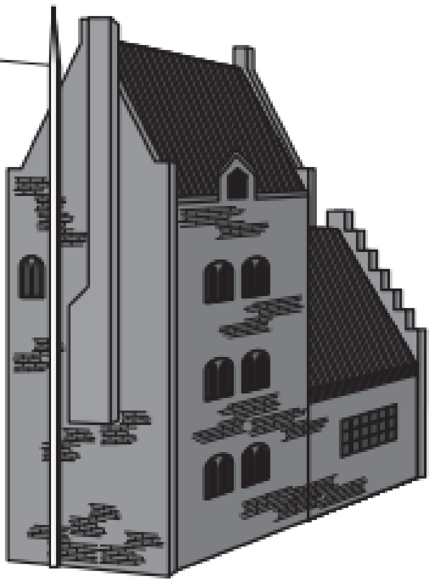
During one lightning strike 24 C of charge is transferred to the ground in 0·0012 s.

(a) Calculate the average current during the lightning strike. **3**

(b) The charge on an electron is $-1{\cdot}6 \times 10^{-19}$ C.

Determine the number of electrons transferred during the lightning strike. **1**

(c) Many tall buildings have a thick strip of metal attached to the side of the building.




This strip is used to protect the building from damage during electrical storms.

Explain how this strip protects the building from damage. **2**

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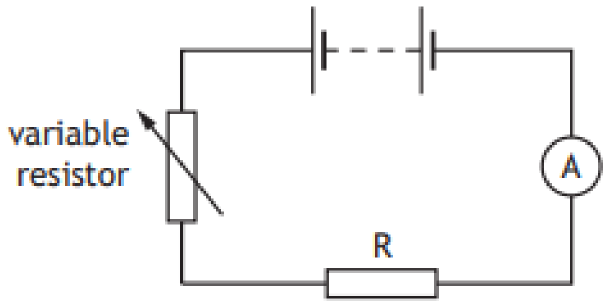
N5 2016 Q 2

2. A student investigates the resistance of a resistor using the circuit shown.




(a) Complete the circuit diagram to show where a voltmeter must be connected to measure the voltage across resistor R. **1**

(An additional diagram, if required, can be found on Page 33.)

(b) Describe how the student obtains a range of values of voltage and current. **1**

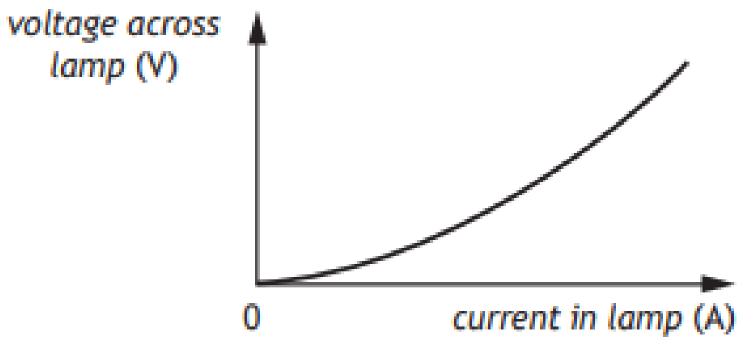
(c) The results of the student's investigation are shown.

| *Voltage across resistor R* (V) | *Current in resistor R* (A) |
|---|---|
| 1·0 | 0·20 |
| 2·5 | 0·50 |
| 3·2 | 0·64 |
| 6·2 | 1·24 |

Use **all** these results to determine the resistance of resistor R. **4**

N5 2016 Q 2 continued

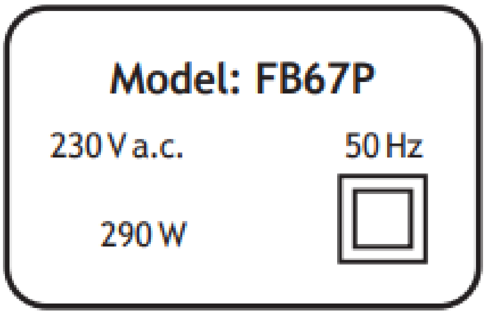
(d) The student now replaces resistor R with a filament lamp and repeats the investigation. A sketch graph of the student's results is shown.




State a conclusion that can be made about the resistance of the filament lamp. **1**

N5 2017 Q 1

**1.** The rating plate on a food blender is shown.




(a) The plugs on all modern electrical appliances in the UK are fitted with fuses rated at either 3 A or 13 A.

(i) Draw the circuit symbol for a fuse. **1**

(ii) State the purpose of the fuse fitted in the plug of an appliance. **1**

(iii) Determine the rating of the fuse fitted in the plug of the blender.

Justify your answer by calculation. **4**

(b) The blender is connected to an alternating current (a.c.) supply.

Explain in terms of electron flow what is meant by *alternating current*. **1**

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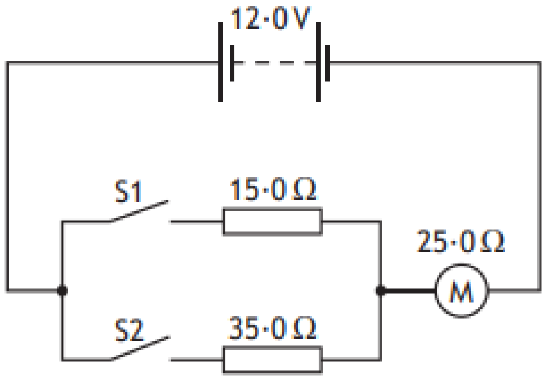
N5 2017 Q 2

**2.** A student sets up the following circuit.




(a) The student closes switch S1.

(i) Calculate the voltage across the motor. **4**

(ii) Calculate the power dissipated in the motor. **3**

(b) The student now also closes switch S2.

(i) Calculate the combined resistance of the two resistors. **3**

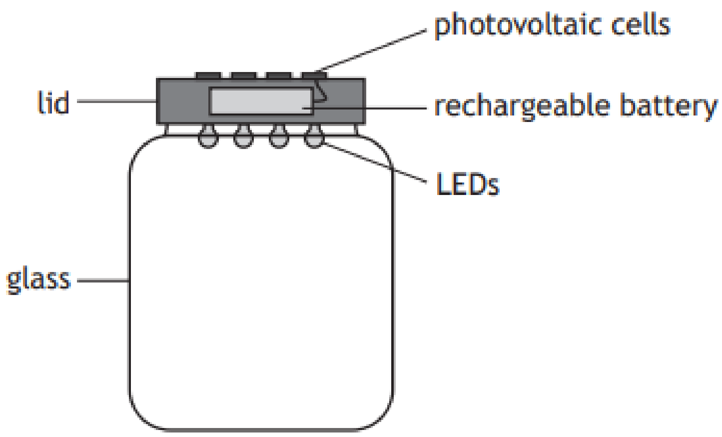
(ii) State the effect that closing switch S2 has on the power dissipated in the motor.

Justify your answer. **3**

N5 2018 Q 6

**6.** A solar jar is designed to collect energy from the Sun during the day and release this energy as light at night.

When the solar jar is placed in sunlight, photovoltaic cells on the lid are used to charge a rechargeable battery.




At night, the rechargeable battery is used to power four identical LEDs.

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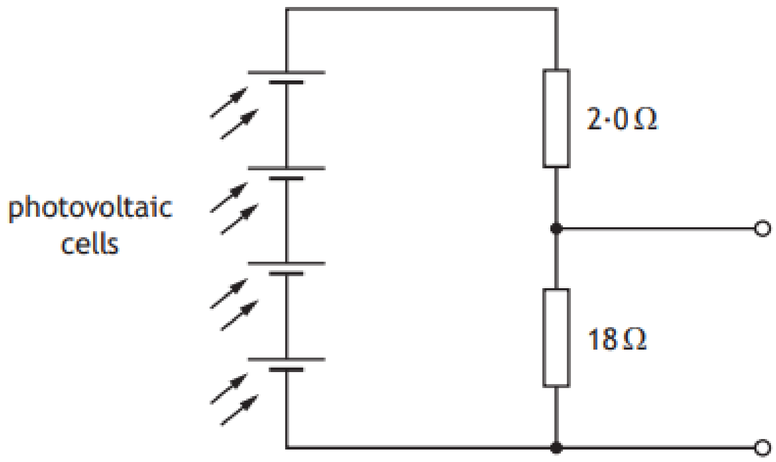
N5 2018 Q 6 continued

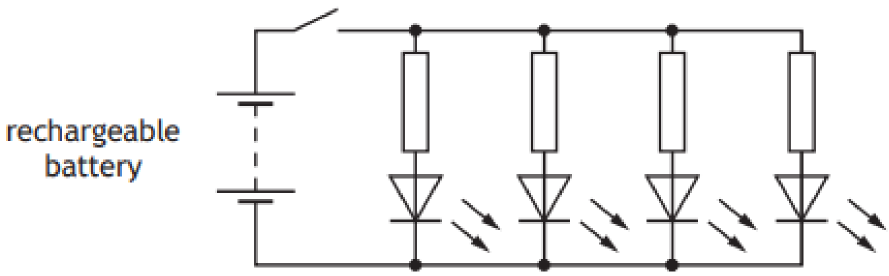
(a) Part of the circuit in the solar jar is shown.




In direct sunlight the photovoltaic cells produce a combined voltage of 4·0 V.

Calculate the voltage across the 18 Ω resistor. **3**

(b) Another part of the circuit containing the LEDs is shown.




The switch is now closed and the LEDs light.

(i) State the purpose of the resistor connected in series with each LED. **1**

(ii) After a few hours the rechargeable battery produces a voltage of 3·4 V.

At this point in time the voltage across each LED is 1·6 V and the current in each LED is 25 mA.

Determine the value of the resistor in series with each LED. **4**

(c) When the battery is completely discharged it then takes 6·0 hours of direct sunlight to fully charge the battery. During this time, there is a constant current of 0·135 A to the battery.

Calculate the total charge supplied to the battery during this time. **3**

*Space for working and answer*

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5. A student is investigating how the length of a wire affects its resistance.

The student connects different lengths of wire to a power supply of fixed voltage and measures the current in each length of wire.

(a) The measurements taken by the student are shown in the table.

| Length of wire (m) | Current (A) |
|---|---|
| 0·20 | 0·94 |
| 0·40 | 0·66 |
| 0·60 | 0·47 |
| 0·80 | 0·37 |
| 1·00 | 0·32 |

(i) Using the graph paper, draw a graph of these measurements. **3**

(ii) State whether the resistance of the wire increases, decreases or stays the same, as the length of wire increases.

Justify your answer. **2**

(iii) Use your graph to predict the current in a 0·50 m length of wire, when connected to the power supply. **1**

(iv) Suggest one way in which the experimental procedure could be improved to give more reliable results. **1**

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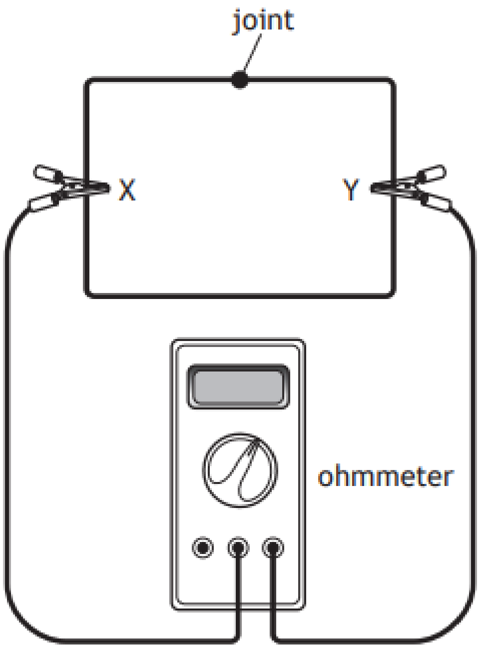
(b) A length of the wire with a resistance of 5·2 Ω is then folded into a rectangular shape and the ends are joined together.

An ohmmeter is connected across the wire between point X and point Y as shown.




State whether the reading on the ohmmeter would be less than, equal to or greater than 5·2 Ω.

You must justify your answer. **2**

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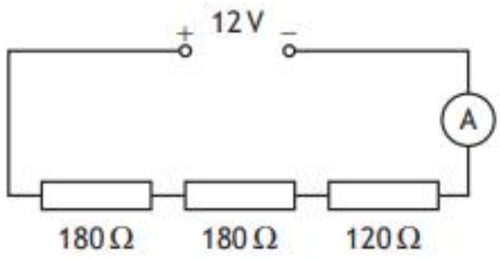
N5 2019 Q 6

**6.** A student is investigating connecting different combinations of resistors in circuits.

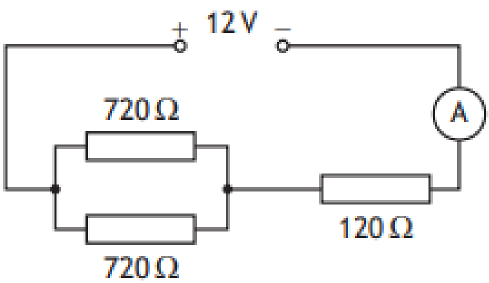
(a) The student sets up a circuit as shown.




(i) Calculate the current in the circuit. **4**

(ii) Calculate the power dissipated in the 120 Ω resistor. **3**

(b) The student then sets up a different circuit as shown.




(i) Determine the total resistance of this circuit. **4**

(ii) State how the power dissipated in the 120 Ω resistor in this circuit compares to the power dissipated in the 120 Ω resistor in the circuit in part (a) (ii).

Justify your answer. **2**

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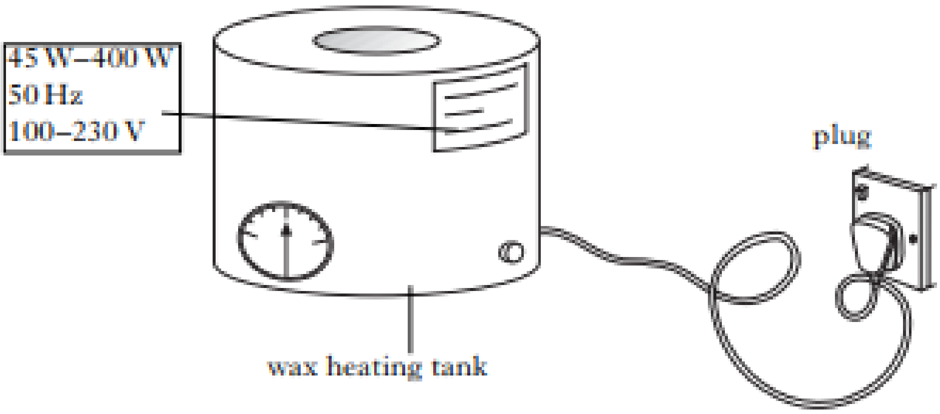
# Transistors

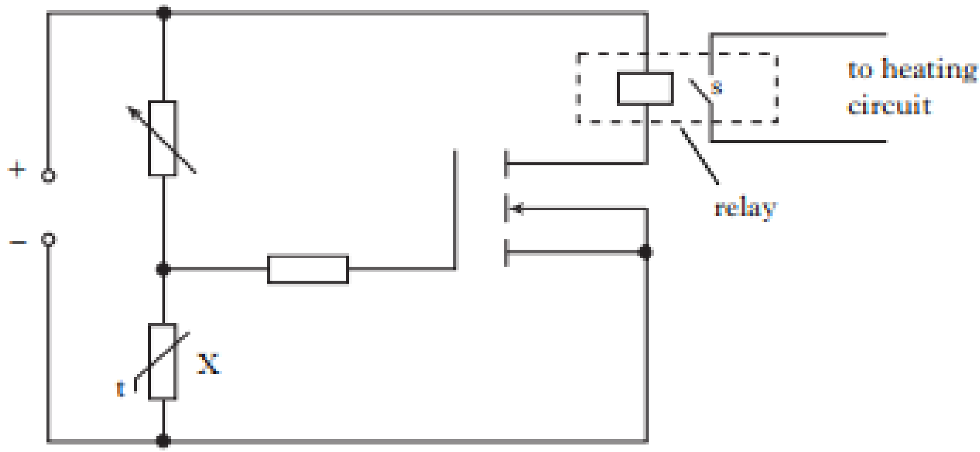
Int 2 2007 Q 26

*Marks*

**26.** 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**

**(5)**

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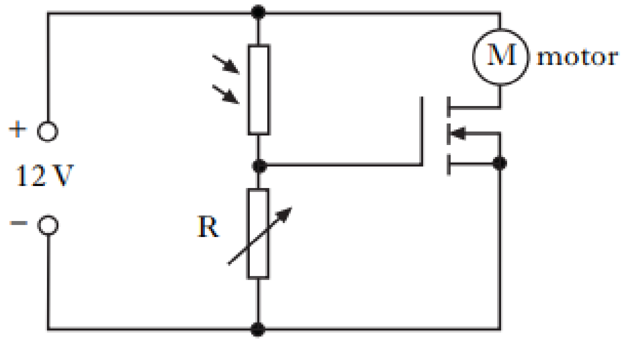
Int 2 2008 Q 27

**27.** An office has an automatic window blind that closes when the light level outside gets too high.

The electronic circuit that operates the motor to close the blind is shown.

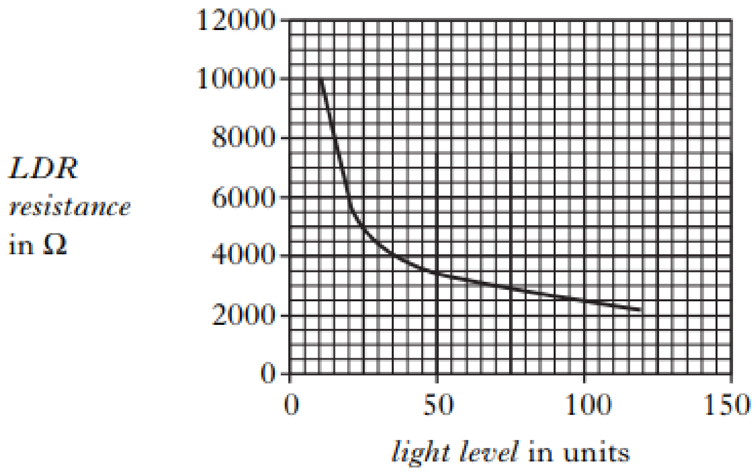



(*a*) The MOSFET switches on when the voltage across variable resistor R reaches 2·4 V.

(i) Explain how this circuit works to close the blind. **3**

(ii) What is the purpose of the variable resistor R? **1**

(*b*) The graph shows how the resistance of the LDR varies with light level.




(i) What is the resistance of the LDR when the light level is 70 units? **1**

(ii) R has a value of 600 Ω. Calculate the voltage across R when the light level is 70 units. **2**

(iii) State whether or not the blinds will close when the light level is 70 units.

Justify your answer. **2**

**(9)**

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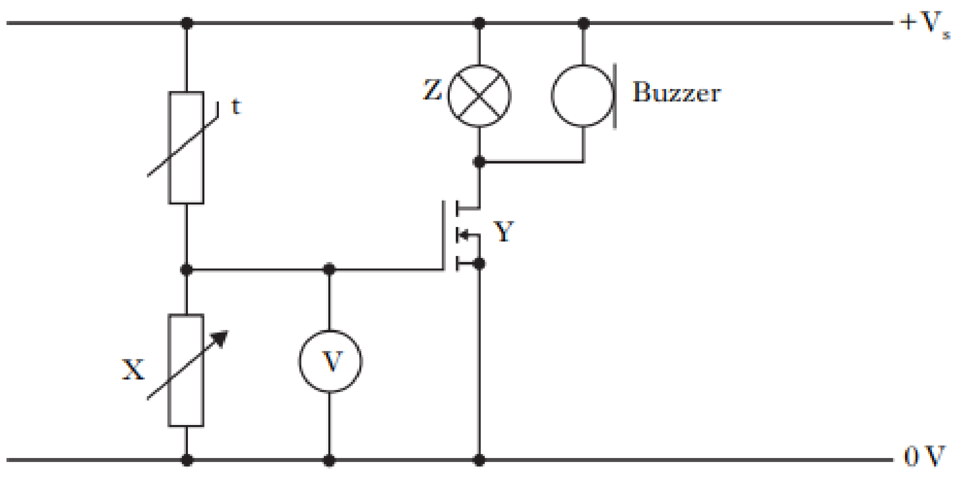
Int 2 2010 Q 26

**26.** Water in a fish tank has to be maintained at a constant temperature. Part of the electronic circuit which controls the temperature is shown.




(*a*) Name components Y and Z. **2**

(*b*) What happens to the resistance of the thermistor as the temperature increases? **1**

(*c*) When the voltmeter reading reaches 1·8 V component Y switches on. Explain how the circuit operates when the temperature rises. **2**

(*d*) Why is a variable resistor chosen for component X rather than a fixed value resistor? **1**

**(6)**

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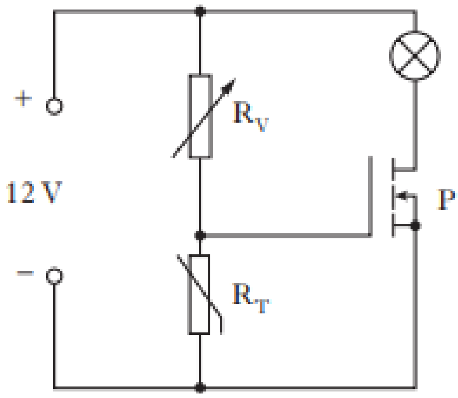
Int 2 2012 Q 25

**25.** 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. What happens to the voltage across $R_T$ as the temperature increases? **1**

(*c*) When the voltage applied to component P is equal to or greater than 2·4 V, component P switches on and the warning lamp lights.

$R_V$ is adjusted until its resistance is 5600 Ω and the warning lamp now lights.

At this point calculate:

(i) the voltage across $R_V$; **1**

(ii) the resistance of $R_T$. **2**

(*d*) The temperature of $R_T$ now decreases.

Will the lamp stay on or go off?

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

**(7)**

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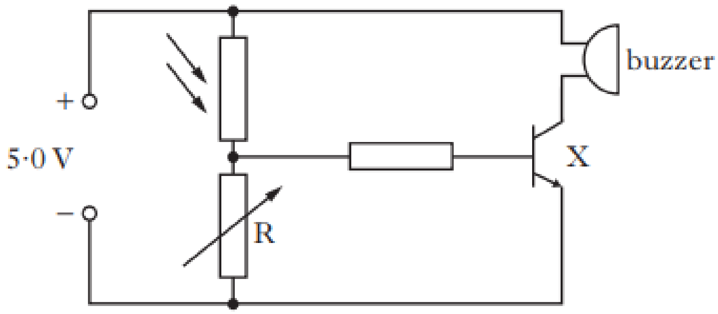
Int 2 2013 Q 28

**28.** 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) What is 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.

| *Light level* (units) | *LDR Resistance* (Ω) |
|---|---|
| 20 | 4500 |
| 50 | 3500 |
| 80 | 2500 |

The variable resistor has a resistance of 570 Ω.

The light level increases to 80 units.

Calculate the current in the LDR. **3**

(*d*) What is the purpose of the variable resistor R in this circuit? **1**

**(9)**

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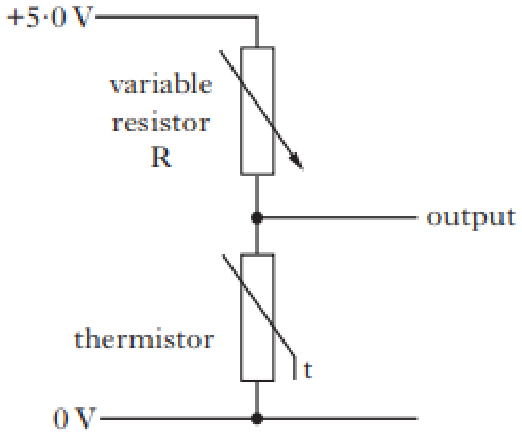
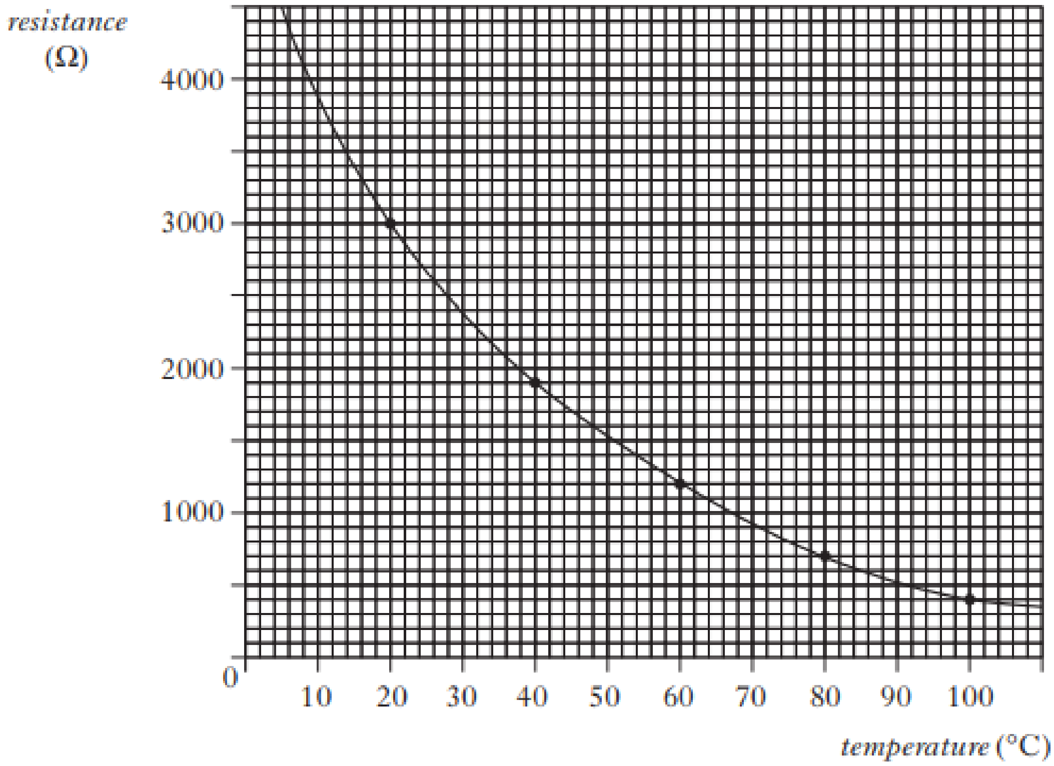
**26.** A thermistor is used as a temperature sensor in a circuit to monitor and control the temperature of water in a tank. Part of the circuit is shown.




(*a*) (i) The variable resistor R is set to a resistance of 1050 Ω. Calculate the resistance of the thermistor when the voltage across the thermistor is 2·0 V. **2**

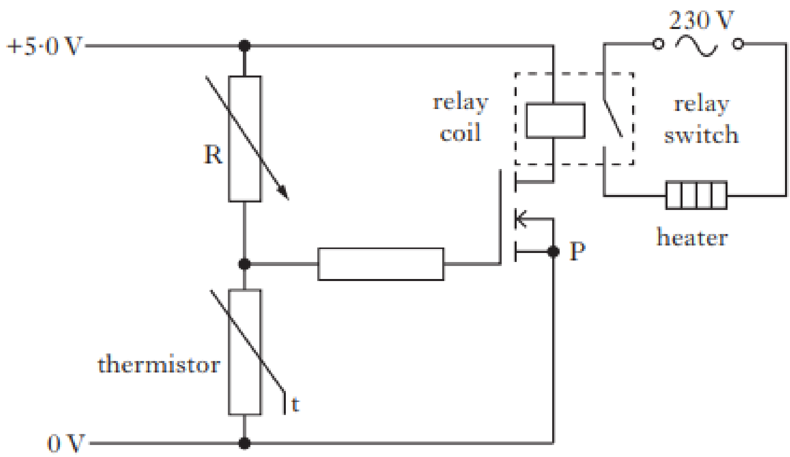
(ii) The graph shows how the resistance of the thermistor changes with temperature.




Use the graph to determine the temperature of the water when the voltage across the thermistor is 2·0 V. **1**

Int 2 2014 Q 26 continued

(*b*) The circuit is now connected to a switching circuit to operate as a heater.




(i) Name component P. **1**

(ii) Explain how the circuit operates to switch on the heater when the temperature falls below a certain value. **3**

(iii) The resistance of the variable resistor R is now increased.

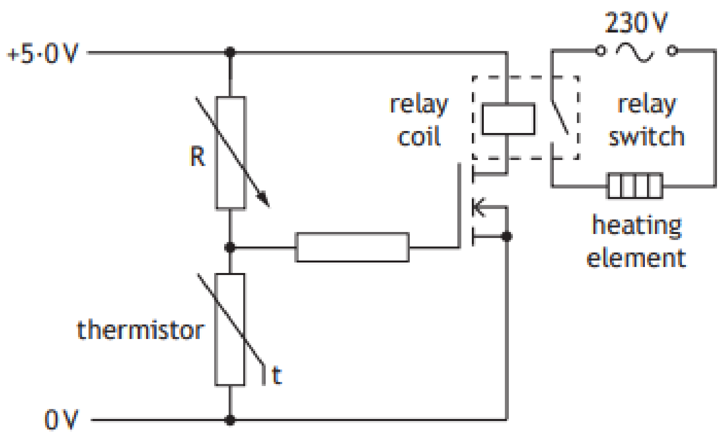
What effect does this have on the temperature at which the heater is switched on?

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

**(9)**

N5 2016 Q 3 c

(c) The temperature of the water in the washing machine is monitored by a circuit containing a thermistor.




As the temperature of the water increases, the resistance of the thermistor decreases.

The heating element is switched off when the temperature of the water reaches 40 °C.

Explain how the circuit operates to **switch off** the heating element. **3**

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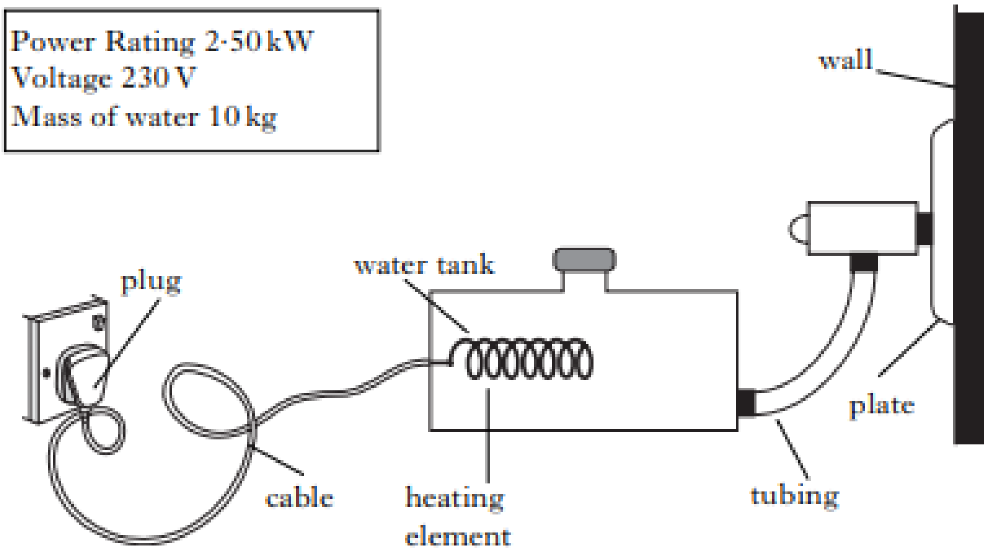
# Heat

Int 2 2007 Q 23

**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)**

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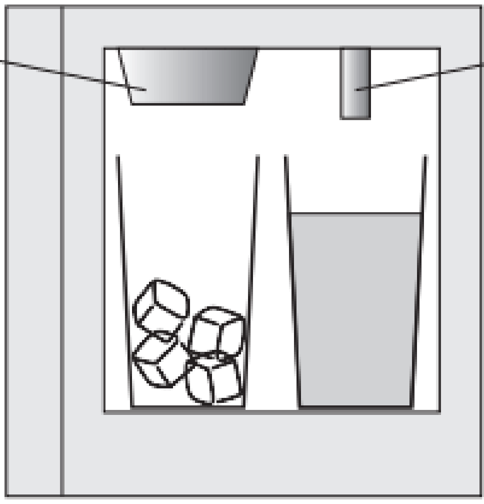
**24.** A fridge/freezer has water and ice dispensers as shown.




(*a*) Water of mass 0·1 kg flows into the freezer at 15 °C and is cooled to 0 °C. Calculate the energy removed when the water cools. **2**

(*b*) Calculate how much energy is released when 0·1 kg of water at 0 °C changes to 0·1 kg of ice at 0 °C. **2**

(*c*) The fridge/freezer system removes heat energy at a rate of 125 J/s.

(i) Calculate the minimum time taken to produce 0·1 kg of ice from 0·1 kg of water at 15 °C. **3**

(ii) Explain why the actual time taken to make the ice will be longer than the value calculated in part (i). **2**

**(9)**

Return to Contents Page

Int 2 2010 Q 23

**23.** On the planet Mercury the surface temperature at night is –173 °C. The surface temperature during the day is 307 °C. A rock lying on the surface of the planet has a mass of 60 kg.

(*a*) The rock absorbs $2{\cdot}59 \times 10^7$ J of heat energy from the Sun during the day.

Calculate the specific heat capacity of the rock. **2**

(*b*) Heat is released at a steady rate of 1440 J/s at night.

Calculate the time taken for the rock to release $2{\cdot}59 \times 10^7$ J of heat. **2**

(*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? **2**

(*d*) Using information from the data sheet, would it be **easier**, **the same** or **more difficult** to lift rocks on Mercury compared to Earth?

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

**(8)**

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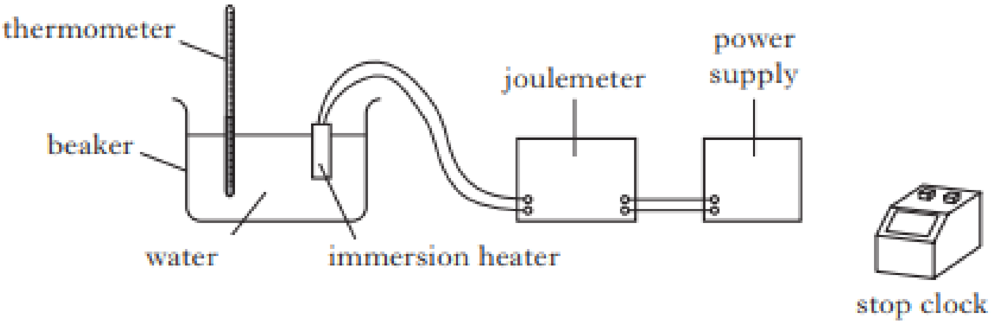
Int 2 2011 Q 24

**24.** 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. **2**

(*b*) (i) The accepted value for the specific heat capacity of water is quoted in the table in the Data Sheet. Explain the difference between the accepted value and the value obtained in the experiment. **2**

(ii) How could the experiment be improved to reduce this difference? **1**

(*c*) Calculate the power rating of the immersion heater. **2**

**(9)**

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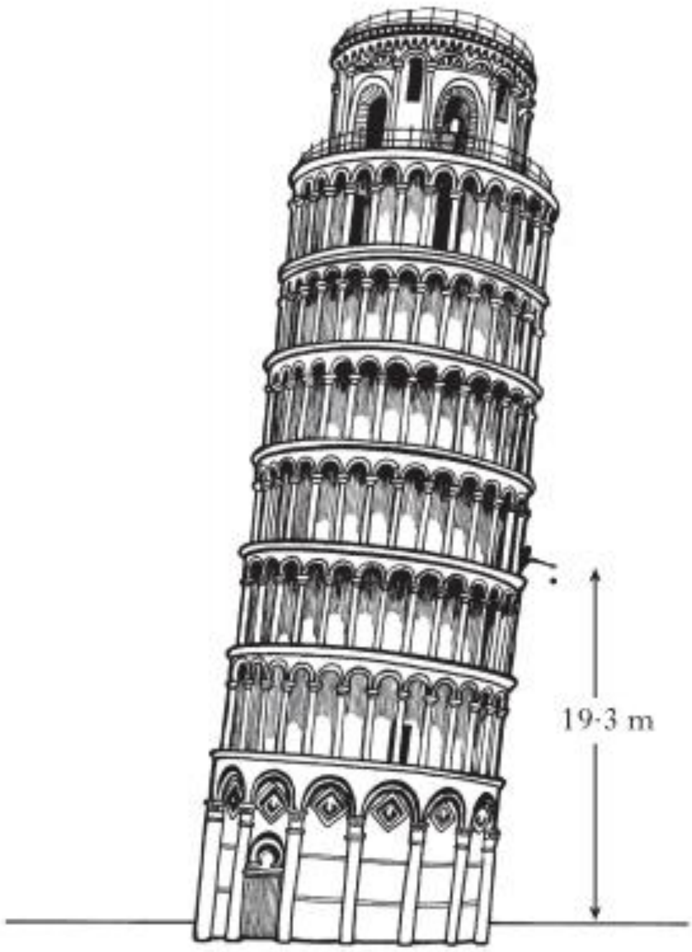
Int 2 2012 Q 23

**23.** A student reproduces Galilleo's famous experiment by dropping a solid copper ball of mass 0·50 kg from a balcony on the Leaning Tower of Pisa.




(*a*) (i) The ball is released from a height of 19·3 m.

Calculate the gravitational potential energy lost by the ball. **2**

(ii) 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. **2**

(iii) Is the actual temperature change of the ball greater than, the same as or less than the value calculated in part (*a*)(ii)?

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

(*b*) The ball was made by melting 0·50 kg of copper at its melting point. Calculate the amount of heat energy required for this. **3**

**(9)**

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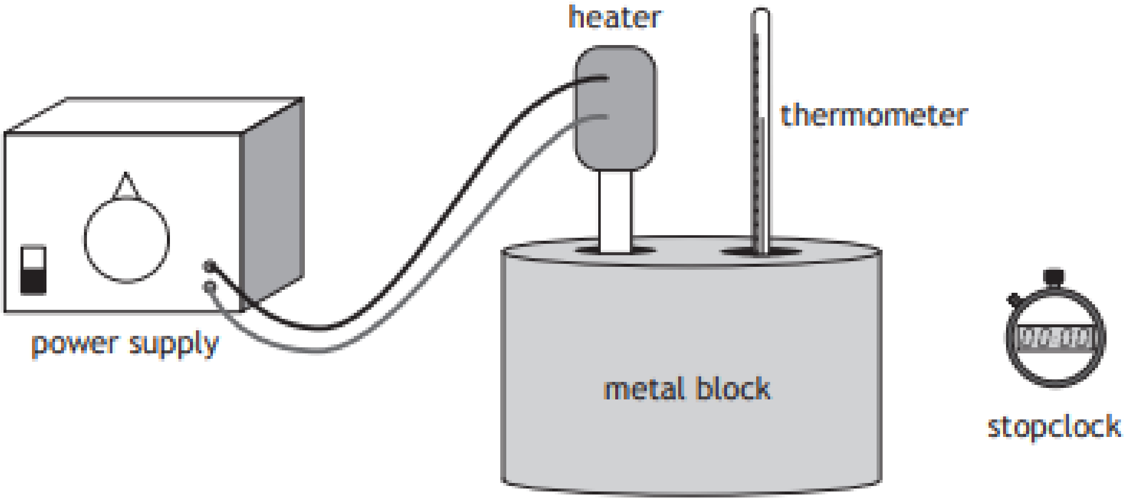
N5 2014 Q 3

3. A student is investigating the specific heat capacity of three metal blocks X, Y and Z.

Each block has a mass of 1·0 kg.

A heater and thermometer are inserted into a block as shown.




The heater has a power rating of 15 W.

The initial temperature of the block is measured.

The heater is switched on for 10 minutes and the final temperature of the block is recorded.

This procedure is repeated for the other two blocks.

The student's results are shown in the table.

| *Block* | *Initial temperature* (°C) | *Final temperature* (°C) |
|---|---|---|
| X | 15 | 25 |
| Y | 15 | 85 |
| Z | 15 | 34 |

(a) Show that the energy provided by the heater to each block is 9000 J. **2**

(b) (i) By referring to the results in the table, identify the block that has the greatest specific heat capacity. **1**

(ii) Calculate the specific heat capacity of the block identified in (b)(i). **3**

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N5 2014 Q 3 continued

(c) Due to energy losses, the specific heat capacities calculated in this investigation are different from the accepted values.

The student decides to improve the set up in order to obtain a value closer to the accepted value for each block.

(i) Suggest a possible improvement that would reduce energy losses. **1**

(ii) State the effect that this improvement would have on the final temperature. **1**

N5 2015 Q 4

**4.** A science technician removes two metal blocks from an oven. Immediately after the blocks are removed from the oven the technician measures the temperature of each block, using an infrared thermometer. The temperature of each block is 230 °C.

After several minutes the temperature of each block is measured again. One block is now at a temperature of 123 °C and the other block is at a temperature of 187 °C.

Using your knowledge of physics, comment on possible explanations for this difference in temperature. **3**

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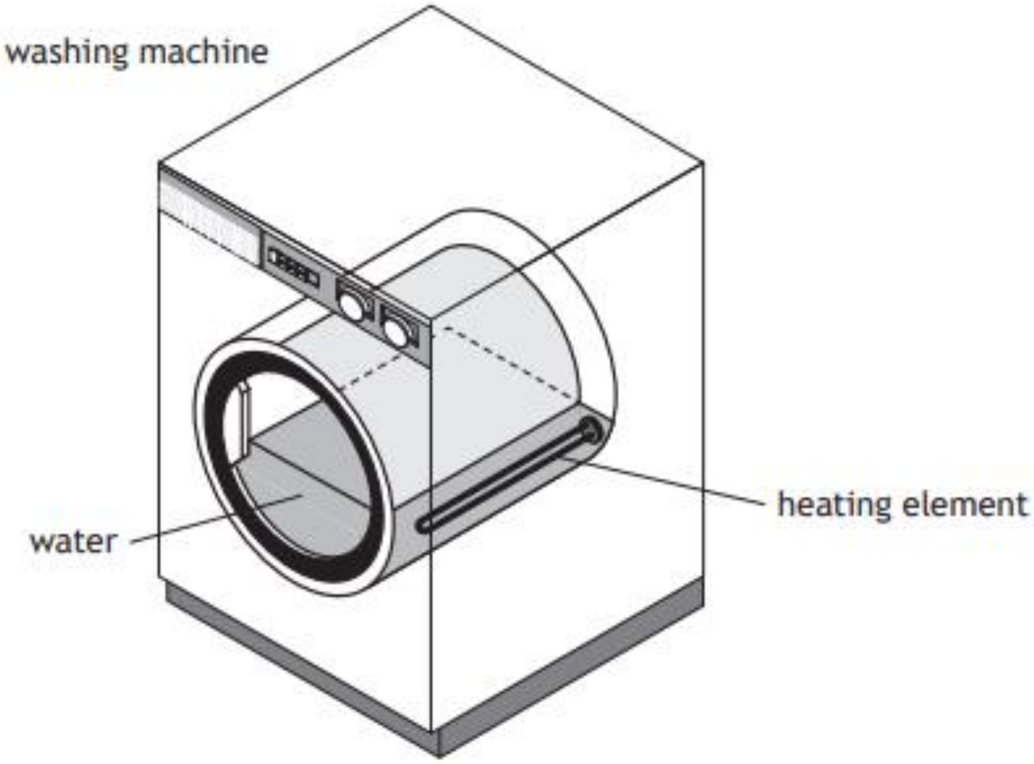
N5 2016 Q 3 a,b

3. A washing machine fills with water at a temperature of 15·0 °C.

The water is heated by a heating element.




(a) The mass of the water in the washing machine is 6·00 kg.

Show that the minimum energy required to increase the temperature of the water from 15·0 °C to 40·0 °C is 627 000 J. **2**

(b) The heating element has a power rating of 1800 W.

(i) Calculate the time taken for the heating element to supply the energy calculated in (a). **3**

(ii) Explain why, in practice, it takes longer to heat the water from 15 °C to 40 °C than calculated in (b)(i). **1**

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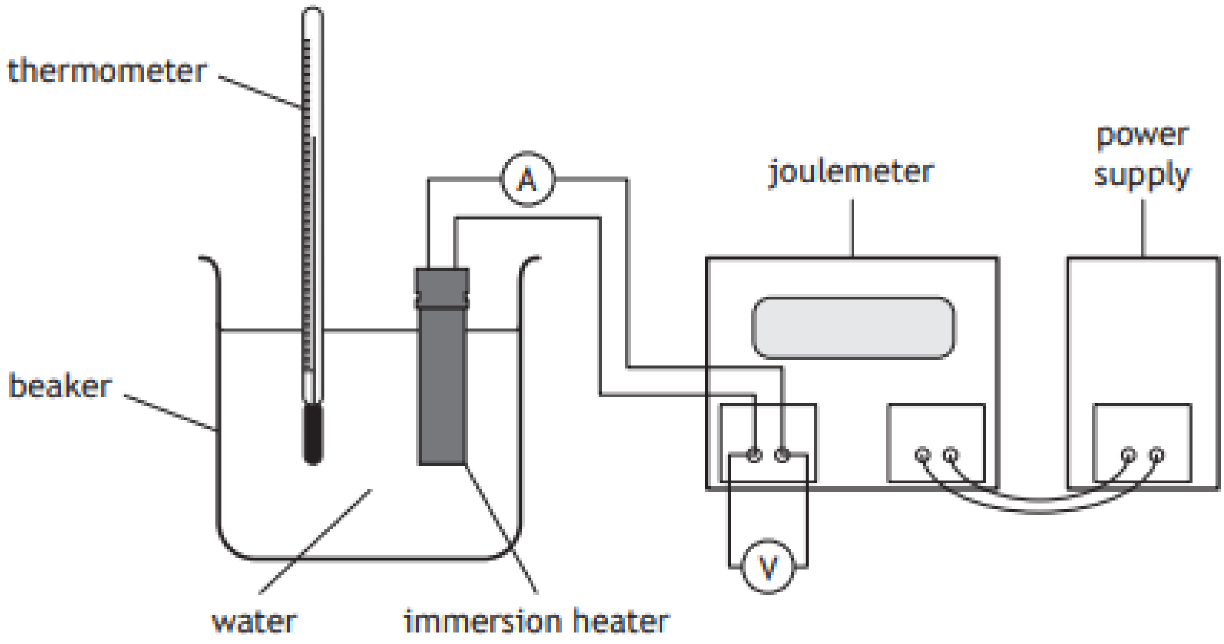
N5 2018 Q 8

8. A student carries out an experiment, using the apparatus shown, to determine a value for the specific heat capacity of water.




The student switches on the power supply and the immersion heater heats the water.

The joulemeter measures the energy supplied to the immersion heater.

The student records the following measurements.

energy supplied to immersion heater = 21 600 J

mass of water = 0·50 kg

initial temperature of the water = 16 °C

final temperature of the water = 24 °C

reading on voltmeter = 12 V

reading on ammeter = 4·0 A

(a) (i) Determine the value of the specific heat capacity of water obtained from these measurements. **3**

(ii) Explain why the value determined from the experiment is different from the value quoted in the data sheet. **1**

(b) Calculate the time for which the immersion heater is switched on in this experiment. **4**

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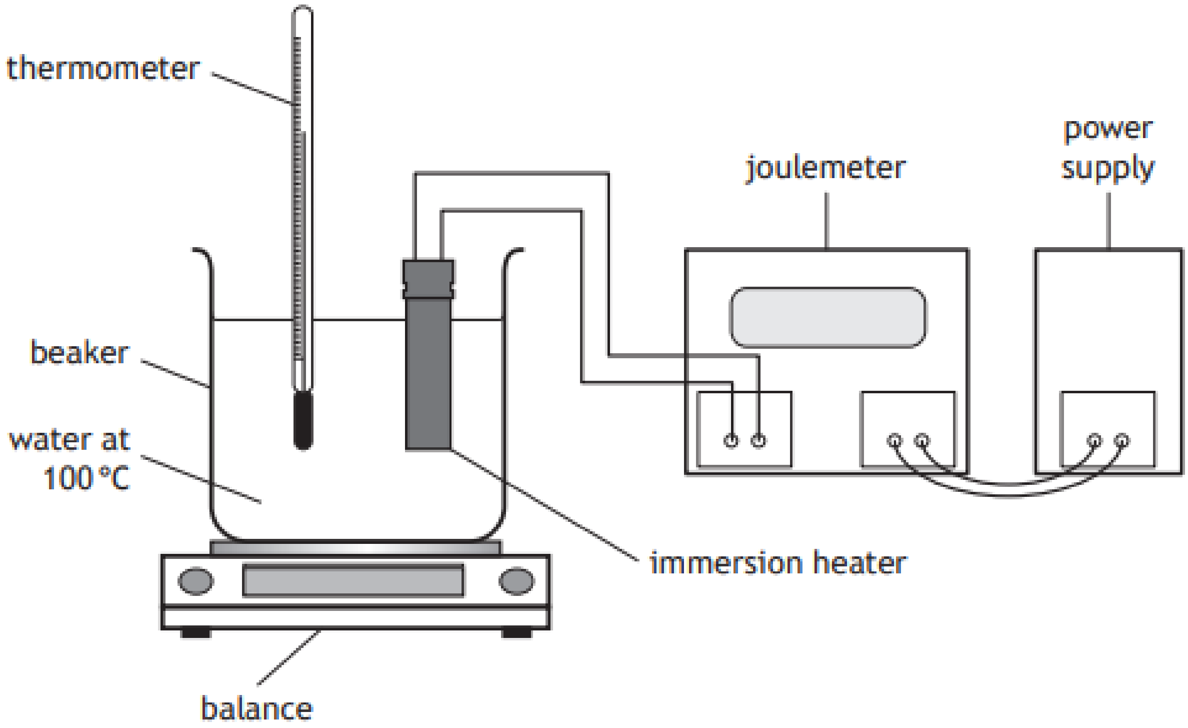
(c) The student then carries out a second experiment, using the apparatus shown, to determine a value for the specific latent heat of vaporisation of water.




Describe how this apparatus would be used to determine a value for the specific latent heat of vaporisation of water. **3**

Your description must include:

- measurements made
- any necessary calculations

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7. A hot water dispenser is used to heat enough water for one cup at a time.

The rating plate for the hot water dispenser is shown.

Model: 1-KUPPA
3·5 kW
230 V
50 Hz

The hot water dispenser takes 26 s to heat enough water for one cup.

(a) Show that the energy supplied to the hot water dispenser during this time is 91 000 J. **2**

(b) The hot water dispenser heats 0·250 kg of water for each cup.

(i) Calculate the minimum energy required to heat 0·250 kg of water from an initial temperature of 20·0 °C to its boiling point. **3**

(ii) As the water is dispensed into the cup, steam is released.

Determine the maximum mass of steam that can be produced while the water for one cup is being heated. **4**

(iii) Explain why, in practice, the mass of steam produced is less than calculated in (b)(ii). **1**

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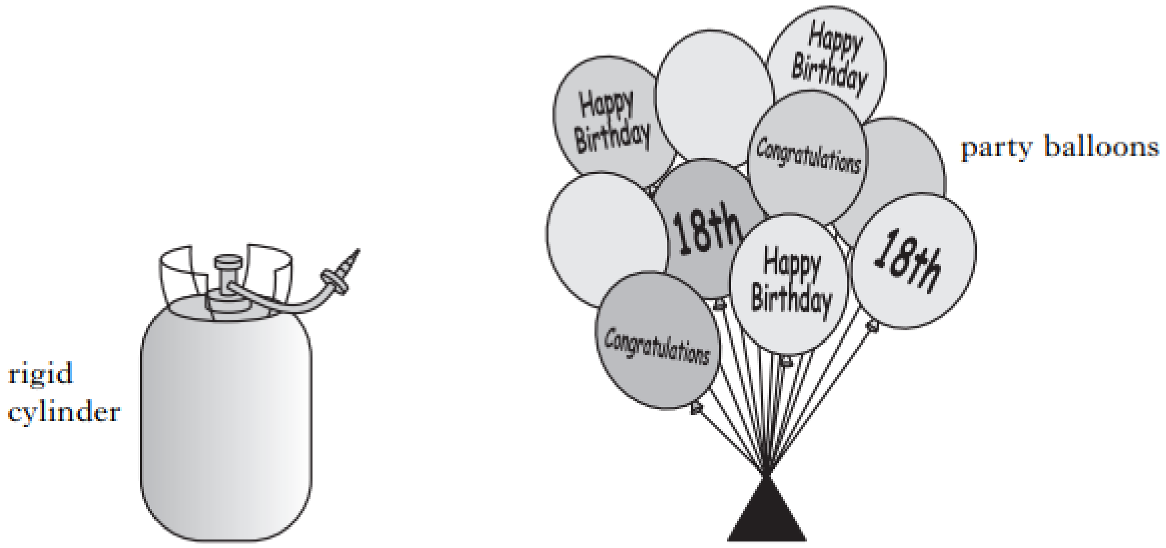
## Kinetic Theory

H 2007 Q 23 a

**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**

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H 2008 Q 23 a(i), b(ii), b(iii)

**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**

(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**

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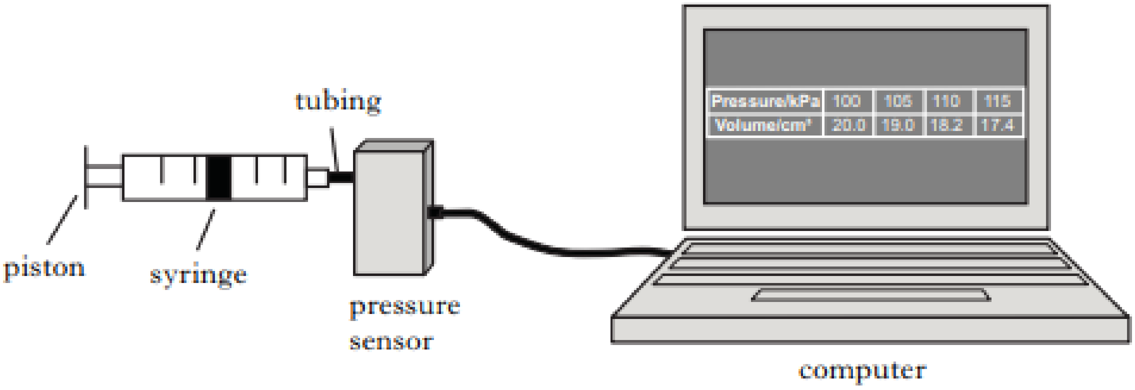
H 2009 Q 23 a,b

**23.** 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*/$cm^3$ | 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. **2**

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H 2010 Q 28 a

**28.** A garden spray consists of a tank, a pump and a spray nozzle.


The tank is partially filled with water.

The pump is then used to increase the pressure of the air above the water.

(*a*) The volume of the compressed air in the tank is $1{\cdot}60 \times 10^{-3}\,m^3$.

The surface area of the water is $3{\cdot}00 \times 10^{-2}\,m^2$.

The pressure of the air in the tank is $4{\cdot}60 \times 10^5\,Pa$.

(i) Calculate the force on the surface of the water. **2**

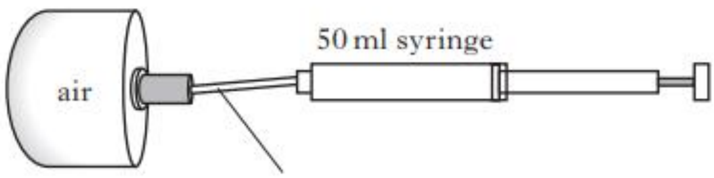
(ii) The spray nozzle is operated and water is pushed out until the pressure of the air in the tank is $1{\cdot}00 \times 10^5\,Pa$.

Calculate the volume of water expelled. **3**

H 2011 Q 23 b

(*b*) Air is allowed back into the bell jar until it reaches a pressure of $1{\cdot}01 \times 10^5\,Pa$.

The technician now uses a syringe to remove 50 ml of the air from the bell jar.




The temperature of the air remains constant.

(i) Calculate the new pressure of the air inside the bell jar. **2**

(ii) Use the kinetic model to explain this change in pressure after removing air with the syringe. **2**

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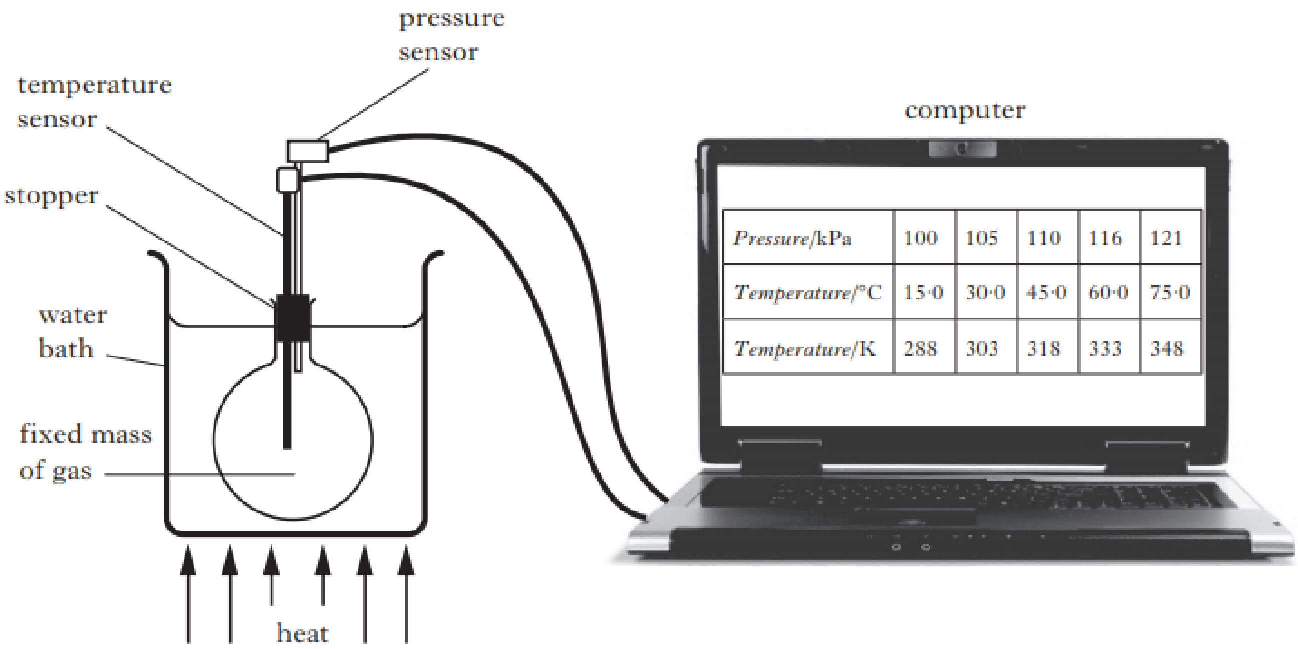
H 2012 Q 24

**24.** 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.

| | | | | | |
|---|---|---|---|---|---|
| *Pressure*/kPa | 100 | 105 | 110 | 116 | 121 |
| *Temperature*/°C | 15·0 | 30·0 | 45·0 | 60·0 | 75·0 |
| *Temperature*/K | 288 | 303 | 318 | 333 | 348 |

(*a*) Using **all** the relevant data, establish the relationship between the pressure and the temperature of the gas. **2**

(*b*) Use the kinetic model to explain the change in pressure as the temperature of the gas increases. **2**

(*c*) Explain why the level of water in the water bath should be above the bottom of the stopper. **1**

**(5)**

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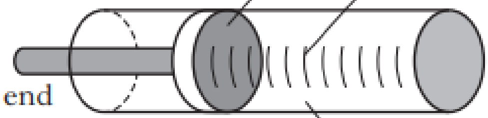
H 2013 Q 22 c

(*c*) After playing with the same ball for a time, the temperature of the gas inside the ball increases.

Using the kinetic model, describe how this increase in temperature affects the pressure of the gas in the ball. Assume that the mass of gas and the volume of the ball remain constant. **2**

H 2013 Q 24 a

**24.** 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. *Marks*




At sea level, the atmospheric pressure is $1{\cdot}01 \times 10^5$ Pa and the trapped gas exerts a force of 262 N on the piston.

(*a*) Calculate the area of the piston. **2**

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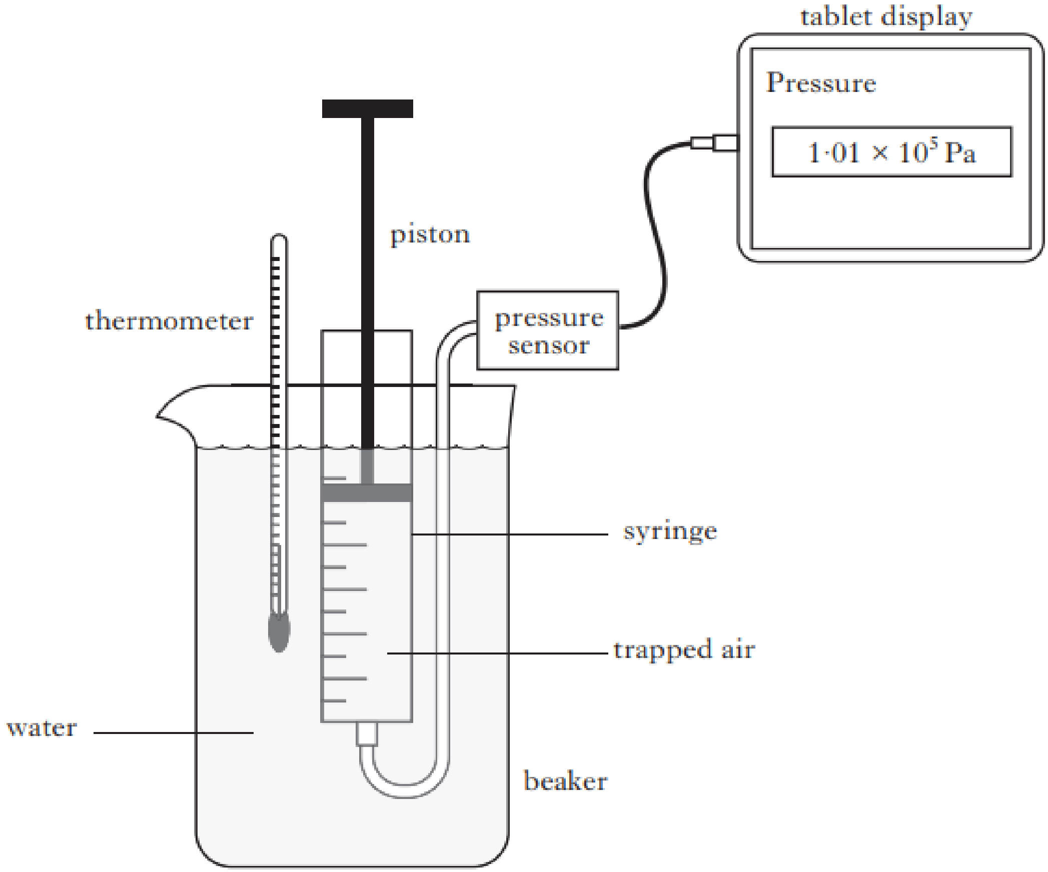
H 2014 Q 24 a(i), a(iii), b

**24.** Air is trapped in a syringe. The mass of the trapped air is $1{\cdot}45 \times 10^{-3}$ kg.

The syringe of trapped air is set up with other apparatus as shown.




(*a*) The trapped air is at a temperature of 20 °C, a pressure of $1{\cdot}01 \times 10^5$ Pa and its volume is $5{\cdot}00 \times 10^{-4}\,m^3$.

The piston on the syringe is now pushed in until the volume of the trapped air is reduced to $1{\cdot}25 \times 10^{-4}\,m^3$.

The temperature of the trapped air remains constant.

(i) Calculate the pressure of the trapped air when its volume is $1{\cdot}25 \times 10^{-4}\,m^3$. **2**

(iii) Use the kinetic model to explain what happens to the pressure of the trapped air as its volume is decreased. **2**

(*b*) The temperature of the trapped air is now increased to 40 °C.

The volume is kept constant at $1{\cdot}25 \times 10^{-4}\,m^3$.

Explain what happens to the density of the trapped air when its temperature is increased. **1**

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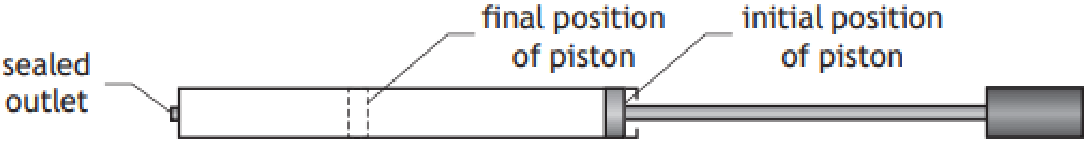
**3.** A bicycle pump with a sealed outlet contains $4{\cdot}0 \times 10^{-4}\,m^3$ of air.

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

The piston of the pump is now pushed slowly inwards until the volume of air in the pump is $1{\cdot}6 \times 10^{-4}\,m^3$ as shown.




During this time the temperature of the air in the pump remains constant.

(a) Calculate the final pressure of the air inside the pump. **3**

(b) Using the kinetic model, explain what happens to the pressure of the air inside the pump as its volume decreases. **3**

(c) The piston is now released, allowing it to move outwards towards its original position.

During this time the temperature of the air in the pump remains constant.

Using the axes provided, sketch a graph to show how the pressure of the air in the pump varies as its volume increases.

Numerical values are not required on either axis. **2**

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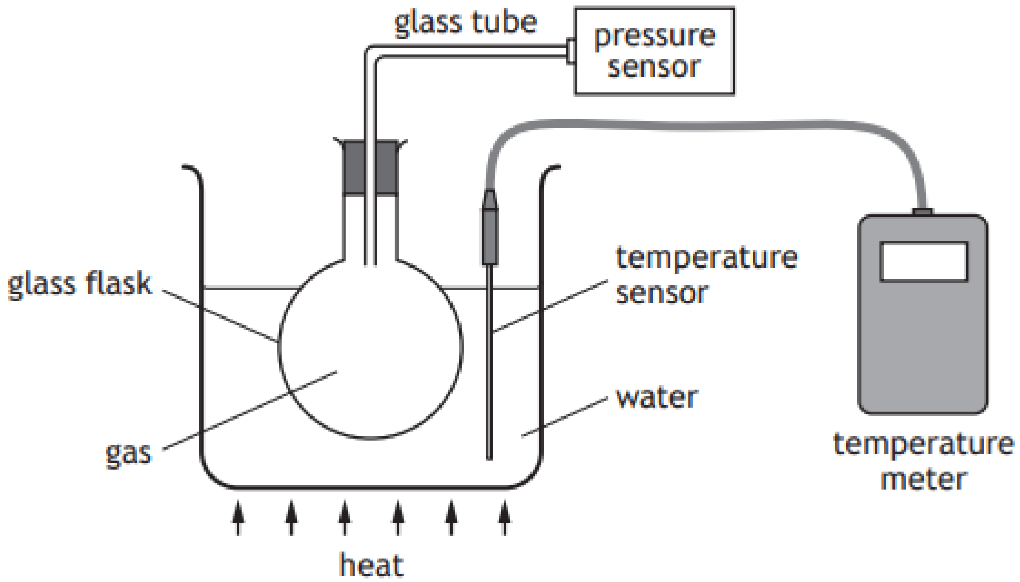
**9.** A student sets up an experiment to investigate the relationship between the pressure and temperature of a fixed mass of gas as shown.




(a) The student heats the water and records the following readings of pressure and temperature.

| | | | | |
|---|---|---|---|---|
| *Pressure* (kPa) | 101 | 107 | 116 | 122 |
| *Temperature* (K) | 293 | 313 | 333 | 353 |

(i) Using **all** the data, establish the relationship between the pressure and the temperature of the gas. **3**

(ii) Using the kinetic model, explain why the pressure of the gas increases as its temperature increases. **3**

(iii) Predict the pressure reading which would be obtained if the student was to cool the gas to 253 K. **1**

(b) State one way in which the set-up of the experiment could be improved to give more reliable results.

Justify your answer. **2**

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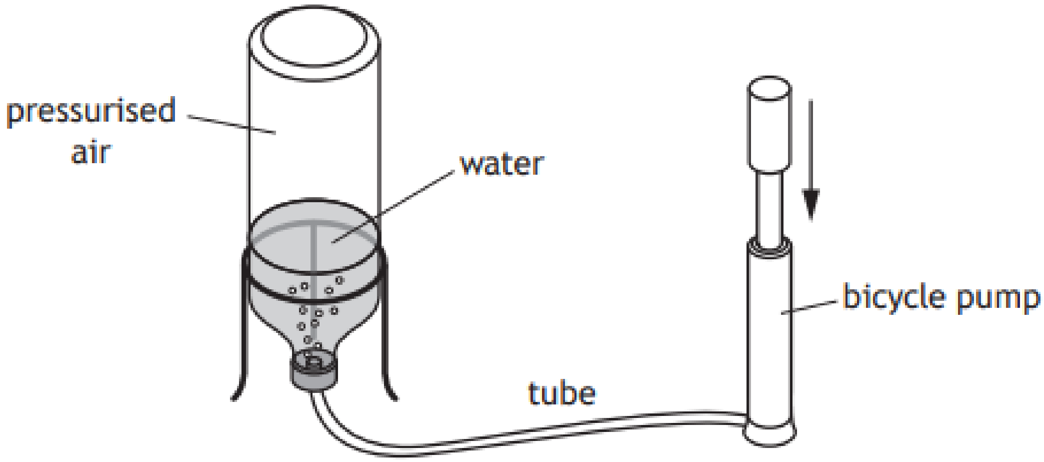
**8.** A water rocket consists of a plastic bottle partly filled with water. Air is pumped in through the water. When the pressure is great enough, the tube detaches from the bottle. Water is forced out of the bottle, which causes the bottle to be launched upwards.




At launch, the air in the bottle is at a pressure of $1{\cdot}74 \times 10^5$ Pa.

(a) On the diagram below, show all the forces acting vertically on the bottle as it is launched.

You must name these forces **and** show their directions. **2**

(b) The area of water in contact with the pressurised air in the bottle is $4{\cdot}50 \times 10^{-3}\,m^2$.

Calculate the force exerted on the water by the pressurised air at launch. **3**

(c) At launch, the air in the bottle has a volume of $7{\cdot}5 \times 10^{-4}\,m^3$.

At one point in the flight, the volume of air in the bottle has **increased by** $1{\cdot}2 \times 10^{-4}\,m^3$.

During the flight the temperature of the air in the bottle remains constant.

(i) Calculate the pressure of the air inside the bottle at this point in the flight. **4**

(ii) Using the kinetic model, explain what happens to the pressure of the air inside the bottle as the volume of the air increases. **3**

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