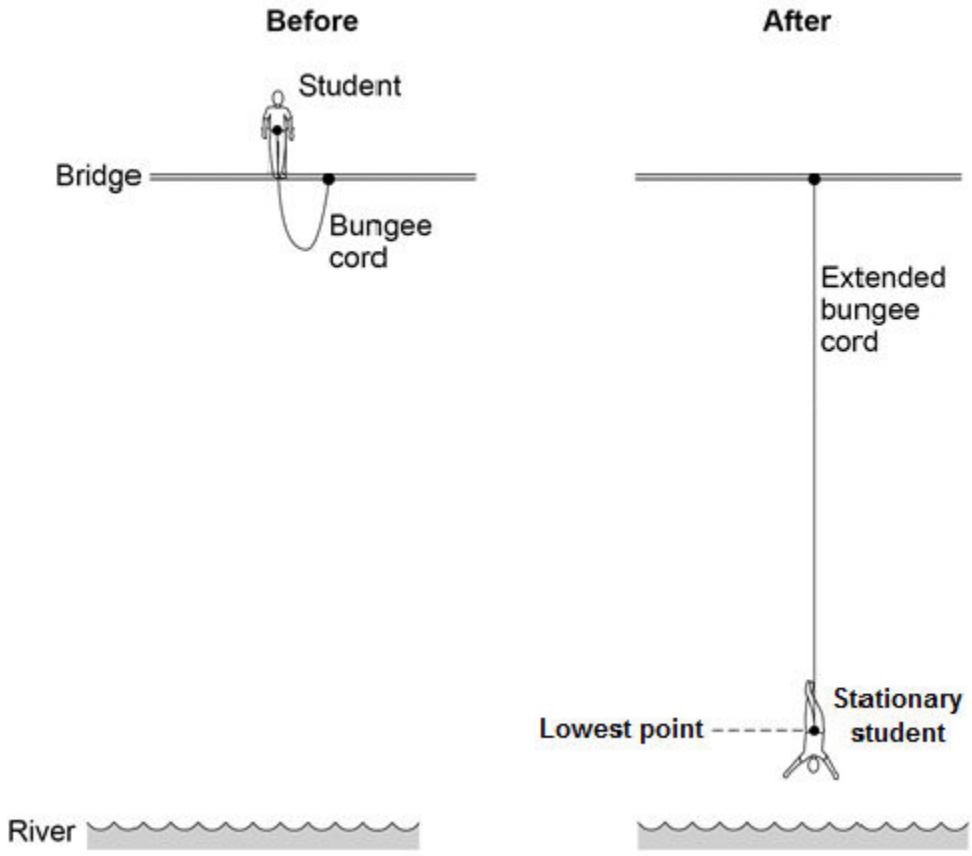
**1** The image below shows a student before and after a bungee jump.

The bungee cord has an unstretched length of 20 m.




(a) For safety reasons, it is important that the bungee cord used is appropriate for the student's weight.

Give **two** reasons why.

1 .....

.....

2 .....

.....

**(2)**

(b) The student jumps off the bridge.

Complete the sentences to describe the energy transfers.

Use answers from the box.

| | | | | |
|---|---|---|---|---|
| **elastic potential** | **gravitational potential** | **kinetic** | **sound** | **thermal** |

Before the student jumps from the bridge he has a store of

..... energy.

When he is falling, the student's store of .....
energy increases.

When the bungee cord is stretched, the cord stores energy as

..... energy.

**(3)**

(c) At the lowest point in the jump when the student is stationary, the extension of the bungee cord is 35 metres.

The bungee cord behaves like a spring with a spring constant of 40 N / m.

Calculate the energy stored in the stretched bungee cord.

Use the correct equation from the Physics Equations Sheet.

.....

.....

.....

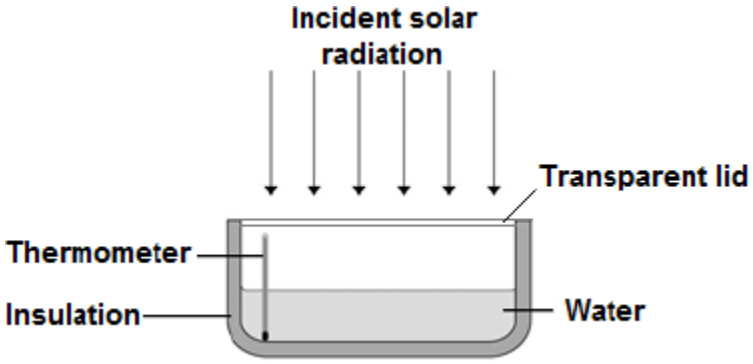
Energy = ..... J

**(2)**
**(Total 7 marks)**

**2** A student investigated how much energy from the Sun was incident on the Earth's surface at her location.

She put an insulated pan of water in direct sunlight and measured the time it took for the temperature of the water to increase by 0.6 °C.

The apparatus she used is shown in the figure below.




(a) Choose the most appropriate resolution for the thermometer used by the student.

Tick **one** box.

0.1 °C ☐

0.5 °C ☐

1.0 °C ☐

**(1)**

(b) The energy transferred to the water was 1050 J.

The time taken for the water temperature to increase by 0.6 °C was 5 minutes.

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

Write down the equation which links energy transferred, power and time.

.....

**(1)**

(c) Calculate the mean power supplied by the Sun to the water in the pan.

.....

.....

.....

Average power = ..... W

**(2)**

(d) Calculate the mass of water the student used in her investigation.

Use the correct equation from the Physics Equation Sheet.

.....

.....

.....

Mass = ..... kg

**(3)**

(e) The student's results can only be used as an estimate of the mean power at her location.

Give **one** reason why.

.....

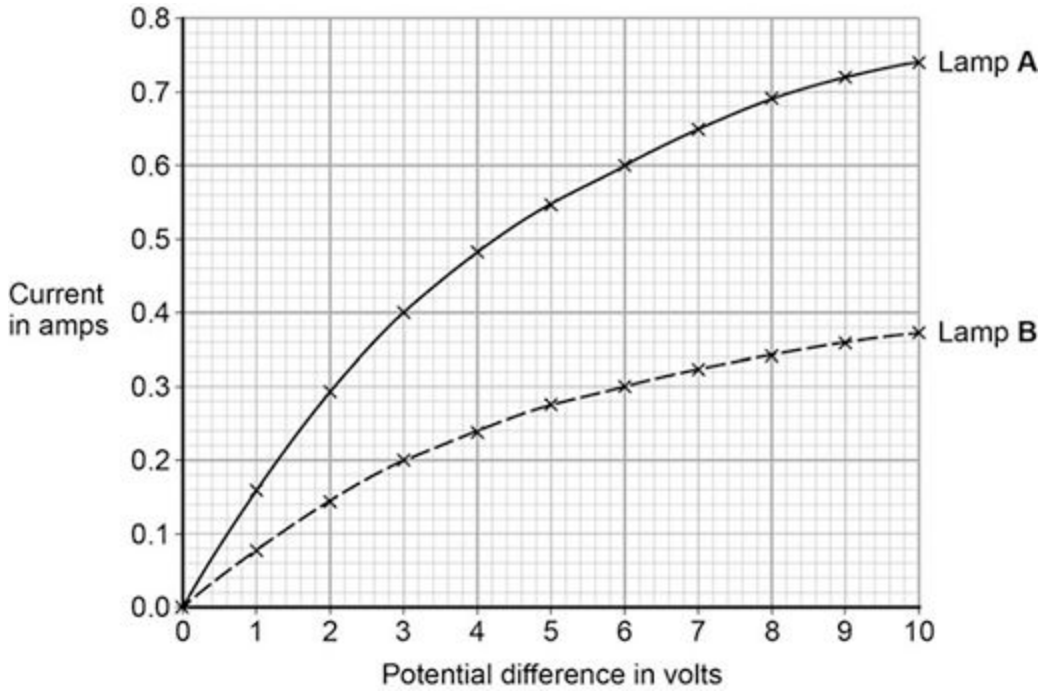
.....

**(1)**

**(Total 8 marks)**

**3** A student investigated how current varies with potential difference for two different lamps.

Her results are shown in the figure below.




(a) Complete the circuit diagram for the circuit that the student could have used to obtain the results shown in the figure above.


**(3)**

(b) Which lamp will be brighter at any potential difference?

Explain your answer.

Use the figure above to aid your explanation

.....

.....

.....

.....

**(2)**

(c) Lamp **B** has the higher resistance at any potential difference.

Explain how the figure above shows this.

.....

.....

.....

.....

**(2)**

(d) Both lamps behave like ohmic conductors through a range of values of potential difference.

Use the figure above to determine the range for these lamps.

Explain your answer.

.....

.....

.....

.....

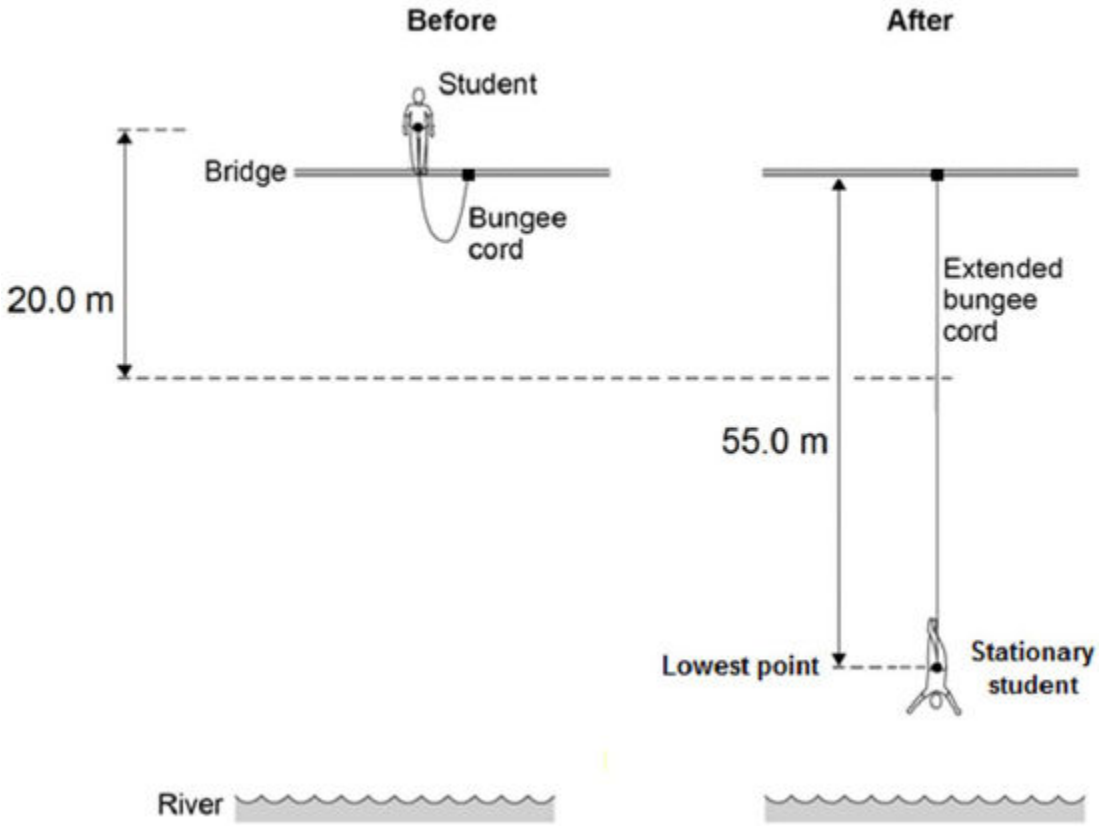
.....

.....

**(3)**
**(Total 10 marks)**

**4** The figure below shows a student before and after a bungee jump.

The bungee cord has an unstretched length of 20.0 m.




The mass of the student is 50.0 kg.

The gravitational field strength is 9.8 N / kg.

(a) Write down the equation which links gravitational field strength, gravitational potential energy, height and mass.

.....

**(1)**

(b) Calculate the change in gravitational potential energy from the position where the student jumps to the point 20.0 m below.

.....

.....

.....

Change in gravitational potential energy = ..... J

**(2)**

(c) 80% of this change in gravitational potential energy has been transferred to the student's kinetic energy store.

How much has the student's kinetic energy store increased after falling 20.0 m?

Kinetic energy gained = ..... J

**(1)**

(d) Calculate the speed of the student after falling 20.0 m.

Give your answer to two significant figures.

.....

.....

.....

.....

Speed = ..... m / s

**(4)**

(e) At the lowest point in the jump, the energy stored by the stretched bungee cord is 24.5 kJ.

The bungee cord behaves like a spring.

Calculate the spring constant of the bungee cord.

Use the correct equation from the Physics Equation Sheet.

.....

.....

.....

.....

.....

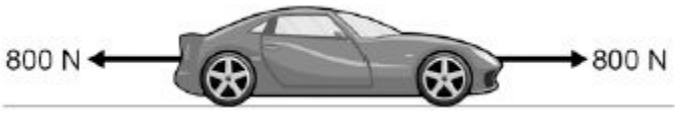
.....

Spring constant = ..... N / m

**(3)**

**(Total 11 marks)**

**5** The figure below shows the horizontal forces acting on a car.




(a) Which **one** of the statements describes the motion of the car?

Tick **one** box.

It will be slowing down. ☐

It will be stationary. ☐

It will have a constant speed. ☐

It will be speeding up. ☐

**(1)**

(b) During part of the journey the car is driven at a constant speed for five minutes.

Which one of the equations links distance travelled, speed and time?

Tick **one** box.

distance travelled = speed + time ☐

distance travelled = speed × time ☐

distance travelled = speed − time ☐

distance travelled = speed ÷ time ☐

**(1)**

(c) During a different part of the journey the car accelerates from 9m / s to 18m / s in 6 s.

Use the following equation to calculate the acceleration of the car.

$$\text{acceleration} = \frac{\text{change in velociy}}{\text{time taken}}$$

.....

.....

acceleration = ..... m / $s^2$

**(2)**

(d) Which equation links acceleration, mass and resultant force?

Tick **one** box.

resultant force = mass + acceleration ☐

resultant force = mass × acceleration ☐

resultant force = mass − acceleration ☐

resultant force = mass ÷ acceleration ☐

**(1)**

(e) The mass of the car is 1120 kg. The mass of the driver is 80 kg.

Calculate the resultant force acting on the car and driver while accelerating.

.....

.....

Resultant force = ..... N

**(2)**

(f) Calculate the distance travelled while the car is accelerating.

Use the correct equation from the Physics Equation Sheet.

.....

.....

.....

Distance = ..... m

**(3)**

(g) A car driver sees a fallen tree lying across the road ahead and makes an emergency stop.

The braking distance of the car depends on the speed of the car.

For the same braking force, explain what happens to the braking distance if the speed doubles.

You should refer to kinetic energy in your answer.

.....

.....

.....

.....

.....

.....

.....

.....

**(4)**

**(Total 14 marks)**

**6** The electric kettle shown below is used to boil water.

©leeser87/iStock

(a) After the water has boiled, the temperature of the water decreases by 22 °C.
The mass of water in the kettle is 0.50 kg.
The specific heat capacity of water is 4200 J/kg °C.

Calculate the energy transferred to the surroundings from the water.

.....

.....

.....

Energy = ..... joules

**(2)**

(b) Why is the total energy input to the kettle higher than the energy used to heat the water?

Tick (✓) **one** box.

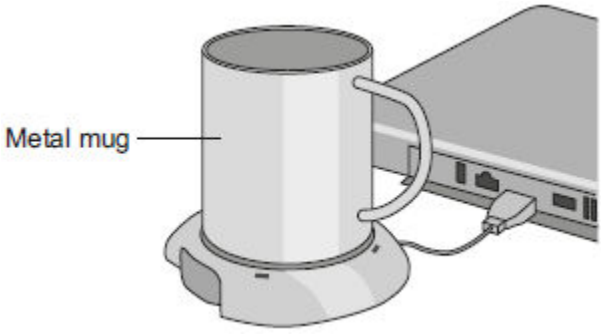
| | **Tick** (✓) |
|---|---|
| Energy is absorbed from the surroundings. | |
| Energy is used to heat the kettle. | |
| The kettle is more than 100% efficient. | |

**(1)**

**(Total 3 marks)**

**7** A heater uses energy from a laptop computer to keep a drink hot.

The image shows a metal mug on the heater.




(a) The laptop computer is operating on battery power.
How would connecting the heater affect the amount of time the laptop computer would operate for, before needing to be recharged?

Tick (✓) **one** box.

| | **Tick** (✓) |
|---|---|
| it would decrease the time | |
| it would not affect the time | |
| it would increase the time | |

**(1)**

(b) The power output from the heater is 12 W.

Calculate the energy transferred to the metal mug in 60 seconds.

.....

.....

.....

Energy = ..... joules

**(2)**

(c) The table lists changes that may affect the energy transfer per second from the heater to the liquid.

Tick (✓) **one** box to show the effect of each change.

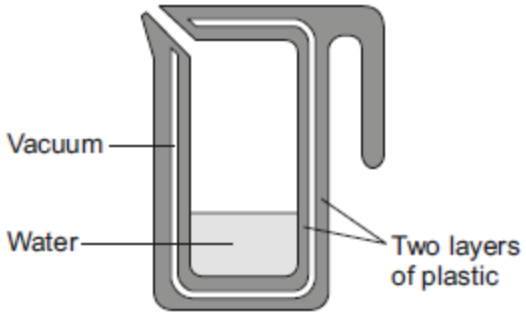
| **Change** | **Energy transfer per second to the liquid** | | |
|---|---|---|---|
| | **increases** | **decreases** | **does not change** |
| use a mug with a smaller base | | | |
| use a lower power heater | | | |
| use a plastic mug instead of a metal mug | | | |

**(3)**

**(Total 6 marks)**

**8** A new design for a kettle is made from two layers of plastic separated by a vacuum. After the water in the kettle has boiled, the water stays hot for at least 2 hours.

The new kettle is shown below.




(a) The energy transferred from the water in the kettle to the surroundings in 2 hours is 46 200 J.

The mass of water in the kettle is 0.50 kg.

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

The initial temperature of the water is 100 °C.

Calculate the temperature of the water in the kettle after 2 hours.

.....

.....

.....

.....

Temperature after 2 hours = ..... °C

**(3)**

(b) Calculate the average power output from the water in the kettle to the surroundings in 2 hours.

.....

.....

.....

.....

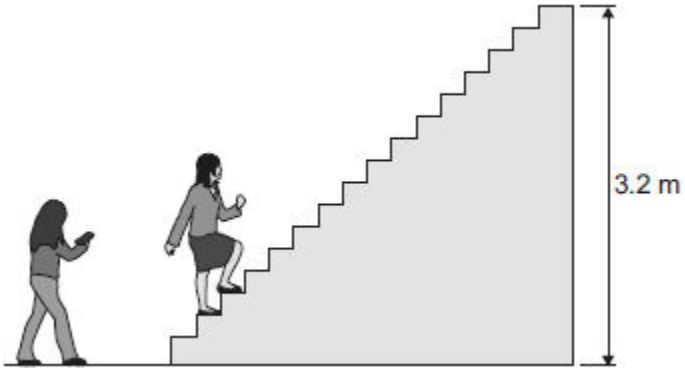
Average power output = ..... W

**(2)**

**(Total 5 marks)**

**9** A student did an experiment to calculate her power.
The diagram below shows how she obtained the measurements needed.

The student first weighed herself and then ran up a flight of stairs. A second student timed how long it took her to go from the bottom to the top of the stairs. The height of the stairs was also measured.




(a) Complete the following sentence.

To run up the stairs the student must do work against

the force of ..... .

**(1)**

(b) The student did 2240 J of work going from the bottom of the stairs to the top of the stairs.

The student took 2.8 seconds to run up the stairs.

(i) Calculate the power the student developed when running up the stairs.

.....

.....

Power = ..... W

**(2)**

(ii) How much gravitational potential energy did the student gain in going from the bottom to the top of the stairs?

Tick (✓) **one** box.

much more than 2240 J ☐

2240 J ☐

much less than 2240 J ☐

**(1)**

(c) Another four students did the same experiment.

The measurements taken and the calculated values for power are given in the table.

| Student | Weight in newtons | Time taken in seconds | Power in watts |
|---|---|---|---|
| **A** | 285 | 3.8 | 240 |
| **B** | 360 | 2.4 | 480 |
| **C** | 600 | 3.4 | 560 |
| **D** | 725 | 4.0 | 580 |

(i) To make a fair comparison of their powers the students kept **one** variable in the experiment constant.

What variable did the students keep constant?

.....

**(1)**

(ii) From the data in the table a student wrote the following conclusion.

'The greater the weight of the student the greater the power developed.'

Suggest why this conclusion may **not** be true for a larger group of students.

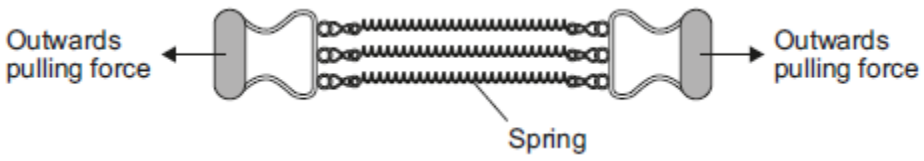
.....

.....

**(1)**
**(Total 6 marks)**

**10** **Figure 1** shows an exercise device called a chest expander. The three springs are identical.

**Figure 1**




A person pulls outwards on the handles and does work to stretch the springs.

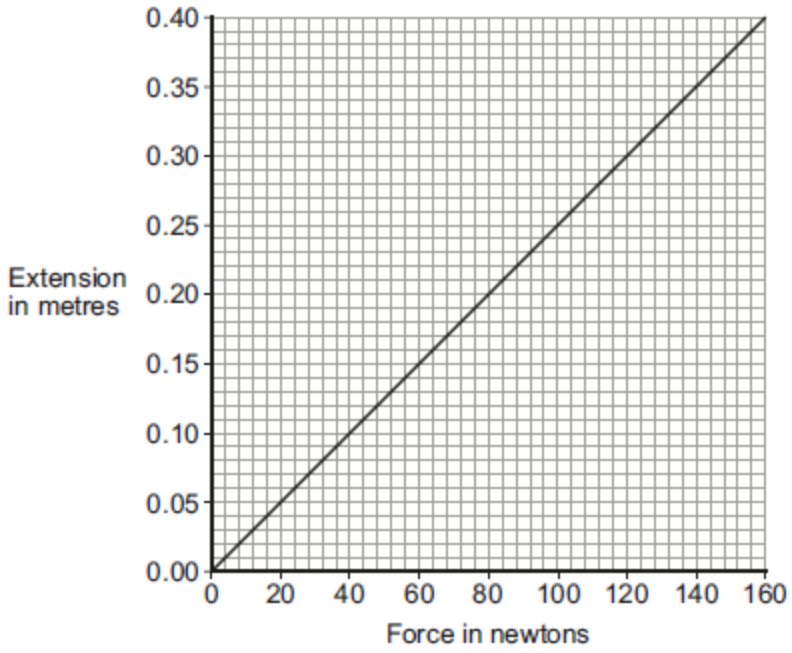
(a) Complete the following sentence.

When the springs are stretched ..... ..... energy is stored in the springs.

**(1)**

(b) **Figure 2** shows how the extension of a single spring from the chest expander depends on the force acting on the spring.

**Figure 2**




(i) How can you tell, from **Figure 2**, that the limit of proportionality of the spring has not been exceeded?

.....

.....

**(1)**

(ii) Use data from **Figure 2** to calculate the spring constant of the spring.
Give the unit.

.....

.....

.....

Spring constant = ..... Unit .....

**(3)**

(iii) Three identical resistors joined in parallel in an electrical circuit share the total current in the circuit.

In a similar way, the three springs in the chest expander share the total force exerted.

By considering this similarity, use **Figure 2** to determine the total force exerted on the chest expander when each spring is stretched by 0.25 m.

.....

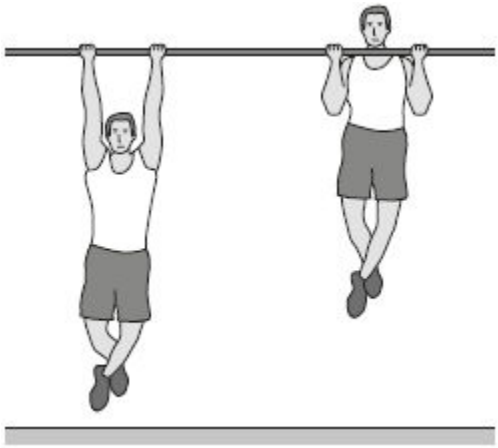
.....

Total force = ..... N

**(2)**

(c) The student in **Figure 3** is doing an exercise called a chin-up.

**Figure 3**



Each time the student does one chin-up he lifts his body 0.40 m vertically upwards.
The mass of the student is 65 kg.
The student is able to do 12 chin-ups in 60 seconds.

Calculate the power developed by the student.

Gravitational field strength = 10 N/kg

.....

.....

.....

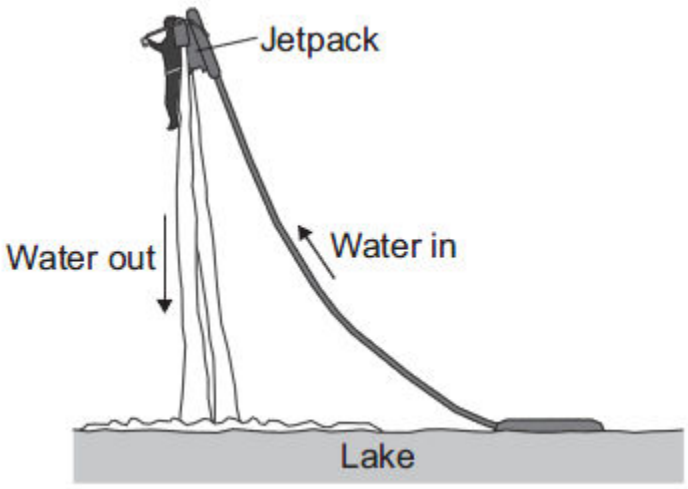
.....

.....

Power = ..... W

**(3)**
**(Total 10 marks)**

**11** The diagram below shows a person using a device called a jetpack. Water is forced downwards from the jetpack and produces an upward force on the person.




(a) State the condition necessary for the person to be able to remain stationary in mid-air.

.....

.....

**(1)**

(b) The person weighs 700 N and the jetpack weighs 140 N.

(i) Calculate the combined mass of the person and the jetpack.

Gravitational field strength = 10 N/kg

.....

.....

.....

Combined mass = ..... kg

**(2)**

(ii) Increasing the upward force to 1850 N causes the person to accelerate upwards.

Calculate the acceleration of the person and the jetpack. Give the unit.

.....

.....

.....

.....

Acceleration = ..... Unit .....

**(3)**

**(Total 6 marks)**

**12** Under the same conditions, different materials heat up and cool down at different rates.

(a) What is meant by specific heat capacity?

.....

.....

.....

.....

**(2)**

(b) Quenching' is a process used to change the properties of steel by cooling it rapidly.

The steel is heated to a very high temperature and then placed in a container of cold water.

(i) A metalworker quenches a steel rod by heating it to a temperature of 900 °C before placing it in cold water. The mass of the steel rod is 20 kg.

The final temperature of the rod and water is 50 °C.

Calculate the energy transferred from the steel rod to the water.

Specific heat capacity of steel = 420 J / kg °C.

.....

.....

.....

Energy transferred = ..... J

**(3)**

(ii) The temperature of the steel rod eventually returns to room temperature.

Compare the movement and energies of the particles in the steel rod and in the air at room temperature.

.....

.....

.....

.....

.....

.....

**(3)**

(iii) When the steel rod is being quenched, the temperature of the water rises to 50 °C. After a few hours the water cools down to room temperature.

Some of the cooling of the water is due to evaporation.

Explain in terms of particles how evaporation causes the cooling of water.

.....

.....

.....

.....

.....

.....

.....

.....

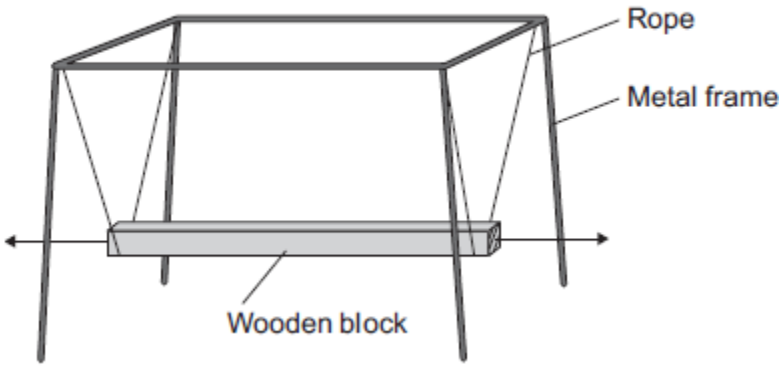
.....

.....

**(4)**
**(Total 12 marks)**

**13** **Figure 1** shows the design of a playground ride.

**Figure 1**




A large wooden block rests on ropes. The ropes are attached to a metal frame.

Children sit on the wooden block.

When the wooden block is moved to the left and released it moves to and fro.

When the wooden block returns to the point of release it has completed one cycle.

(a) Identify **two** possible hazards of the ride in **Figure 1**.

.....

.....

.....

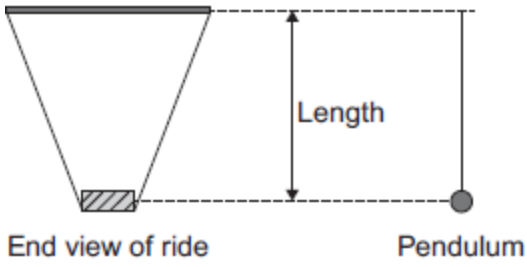
.....

**(2)**

(b) The designer of the ride wants to know if the ride has the same time period as a pendulum of the same length.

The designer used a model of the ride and a pendulum as shown in **Figure 2**.

**Figure 2**




The designer measured the time taken to complete 10 cycles for different lengths of both the model ride and the pendulum.

The results for the model ride are shown in **Table 1**.

**Table 1**

| Length in metres | Time for 10 cycles in seconds | | | | Mean time period in seconds |
|---|---|---|---|---|---|
| | First time | Second time | Third time | Mean | |
| 0.100 | 6.36 | 6.37 | 6.29 | 6.34 | 0.63 |
| 0.150 | 7.76 | 7.74 | 7.80 | | |
| 0.200 | 8.97 | 8.99 | 8.95 | 8.97 | 0.90 |

The results for the pendulum are shown in **Table 2**.

**Table 2**

| Length in metres | Time for 10 cycles in seconds | | | | Mean time period in seconds |
|---|---|---|---|---|---|
| | First time | Second time | Third time | Mean | |
| 0.250 | 10.00 | 10.04 | 10.02 | 10.02 | 1.00 |
| 0.300 | 10.99 | 11.01 | 10.94 | 10.98 | 1.10 |
| 0.350 | 11.88 | 11.83 | 11.87 | 11.86 | 1.19 |

(i) Complete **Table 1**, giving values to an appropriate number of significant figures.

.....

.....

**(3)**

(ii) The investigation already includes repeated readings.

Suggest **one** improvement that could be made to this investigation.

.....

.....

**(1)**

(iii) The designer reads in an Advanced Physics textbook that:
'The square of the time period, $T$, for a simple pendulum is proportional to its length, $l$.'

$$T^2 \propto l$$

Would the model ride have the same time period as a simple pendulum of the same length?

Use **one** row of data from **Table 1** and **one** row of data from **Table 2** to work out your answer.

State your conclusion.

.....

.....

.....

.....

.....

.....

**(3)**

(c) The ride was redesigned and built to make it safer.

The wood was moving at maximum speed. The maximum kinetic energy of the wood was 180 J.

A parent applied a force to the wood and stopped it in a distance of 0.25 m.

Calculate the force required.

.....

.....

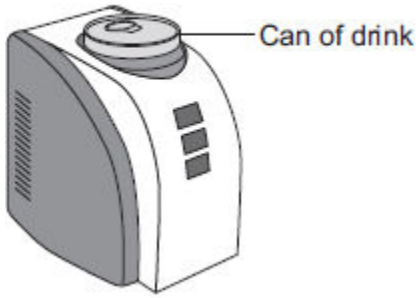
Force = ..... N

**(3)**
**(Total 12 marks)**

**14** A 'can-chiller' is used to make a can of drink colder.

**Figure 1** shows a can-chiller.

**Figure 1**




(a) The can-chiller decreases the temperature of the liquid in the can by 15 °C.
The mass of liquid is 0.33 kg.
The specific heat capacity of the liquid is 4200 J / kg °C.

Calculate the energy transferred from the liquid as it cools.

.....

.....

.....

Energy = ..... J

**(2)**

(b) Complete the following sentence.

The specific heat capacity of a substance is the amount of energy required to

change the ..... of one kilogram of the

substance by one degree Celsius.

**(1)**

(c) To calculate the specific heat capacity of a material, the mass of the material needs to be measured.

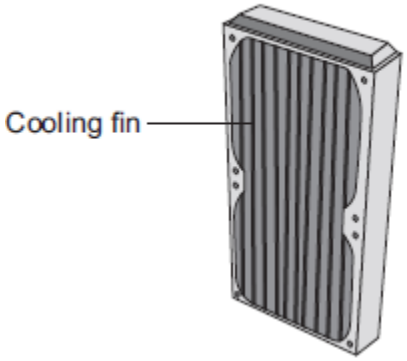
State the name of a measuring instrument used to measure mass.

.....

**(1)**

(d) The back of the can-chiller has cooling fins, as shown in **Figure 2**.

**Figure 2**




The cooling fins increase the rate of energy transfer from the can-chiller to the surroundings.

Complete the following sentences.

The cooling fins are a ..... colour because that makes them

good emitters of infrared radiation.

The large surface area of the cooling fins allows the air around the can-chiller

to gain energy quickly and rise, transferring energy by ..... .

**(2)**

(e) (i) The energy input to the can-chiller is the same as the energy output. This shows that energy is conserved.

Complete the following sentence.

Energy can be transferred usefully, stored or dissipated, but cannot be

..... or destroyed.

**(1)**

(ii) The temperature of the can of drink decreases while it is in the can-chiller.

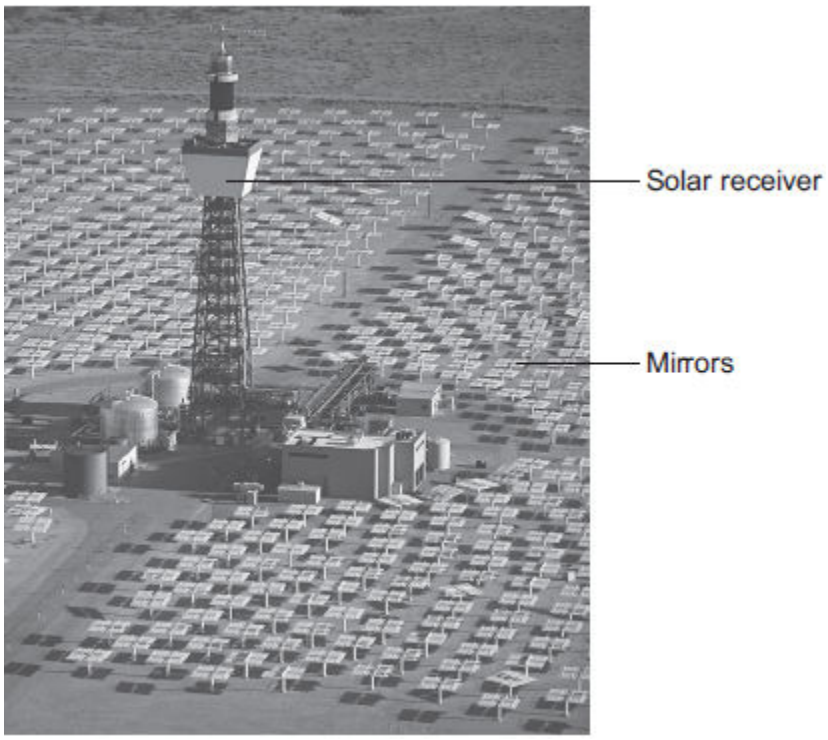
What happens to the temperature of the air around the cooling fins?

.....

**(1)**

**(Total 8 marks)**

**15** The image shows a solar thermal power station.






Energy from the Sun is directed at the solar receiver by many mirrors.

(a) (i) Suggest **one** reason why a solar thermal power station is built in a hot desert.

.....

.....

**(1)**

(ii) Complete the following sentence to describe how the mirrors direct energy from the Sun towards the solar receiver.

Energy from the Sun is ..... by the mirrors

towards the solar receiver.

**(1)**

(iii) Heated water is used to generate electricity in the solar thermal power station. Choose the correct answer from the box to complete each sentence.

| **boiler** | **motor** | **transformer** | **turbine** |
|---|---|---|---|

At the solar receiver, water is heated in a .....

which turns the water into steam. The steam turns a

.....which is connected to a water into steam. The

steam turns a ..... which is connected to a generator.

The generator produces electricity. A ..... is used

to change the voltage for transmission along power lines.

**(3)**

(b) A solar storage power station is a new type of solar power station.
It is able to store energy from the Sun to generate electricity at night.

The solar storage power station can supply a town with a maximum electrical power of 140 000 kW for 15 hours.

Calculate the maximum energy, in kWh, stored by the solar storage power station.

.....

.....

.....

Energy = ..... kWh

**(2)**

(c) A different method of generating electricity uses wind turbines.
A student researching a wind farm wrote the following.

> Top Hill Wind Farm has 25 wind turbines.
> Last week, one of the wind turbines generated electricity for only 42 hours out of a possible 168 hours.
> My conclusion is that all wind turbines operate for only 25% of the time.

(i) Give **two** reasons why the student is **not** correct in reaching his conclusion.

1.....

.....

2.....

.....

**(2)**

(ii) Give **one** reason why wind turbines do not generate electricity all the time.

.....

.....

**(1)**

(iii) Give **one** advantage of using wind turbines to generate electricity compared with using fossil fuel power stations.

.....

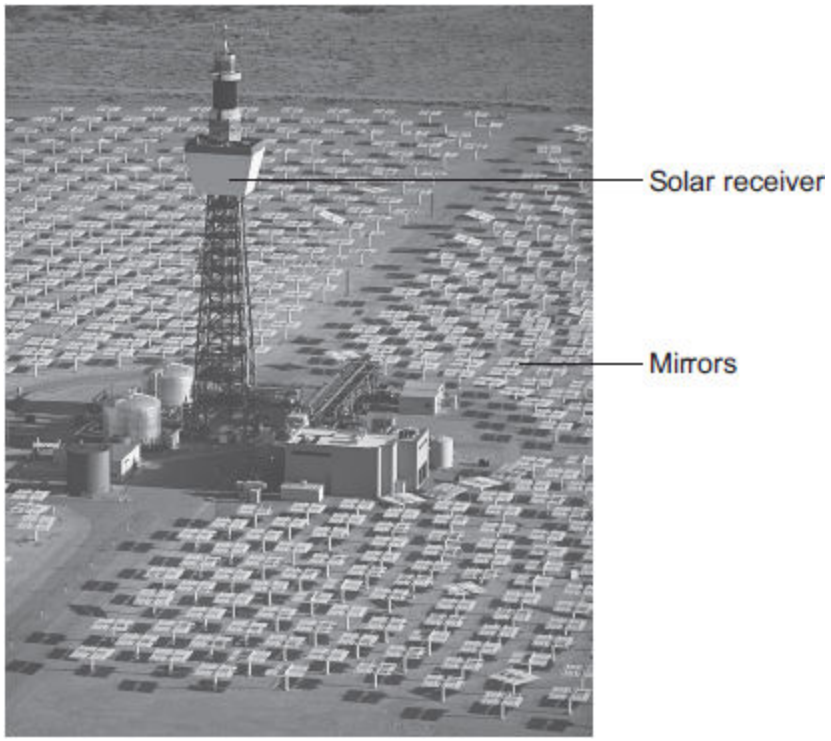
.....

**(1)**
**(Total 11 marks)**

**16** The image below shows a solar thermal power station that has been built in a hot desert.

The power station uses energy from the Sun to heat water to generate electricity.

Energy from the Sun is reflected towards a solar receiver using many mirrors.






(a) (i) Which part of the electromagnetic spectrum provides most of the energy to heat the water in a solar thermal power station?

.....

**(1)**

(ii) Describe how heated water is used to generate electricity by this solar thermal power station.
The process is the same as in a fossil fuel power station.

.....

.....

.....

.....

.....

.....

**(3)**

(b) A new type of solar power station, called a solar storage power station, is able to store energy from the Sun by heating molten chemical salts.
The stored energy can be used to generate electricity at night.

(i) It is important that the molten chemical salts have a high specific heat capacity.
Suggest **one** reason why.

.....

.....

**(1)**

(ii) The solar storage power station can store a maximum of 2 200 000 kWh of energy.
The solar storage power station can supply a town with a maximum electrical power of 140 000 kW.

Calculate for how many hours the energy stored by the solar storage power station can supply the town with electrical power.

Give your answer to 2 significant figures.

.....

.....

.....

Time = ..... hours

**(3)**

(iii) **Table 1** gives information about the place where the solar storage power station has been built.

**Table 1**

| **Season** | **Mean number of daylight hours** | **Mean power received from the Sun per square metre in kW** |
|---|---|---|
| Spring | 11.5 | 0.90 |
| Summer | 13.5 | 1.10 |
| Autumn | 12.0 | 0.95 |
| Winter | 10.5 | 0.71 |

The solar storage power station does not operate at the maximum possible electrical output every day of the year.

Suggest why.

.....

.....

.....

.....

**(2)**

(c) Power stations do not work at maximum possible electrical output all the time.The 'capacity factor' of a power station is calculated using the equation:

$$\text{Capacity factor} = \frac{\text{actual electrical output per year}}{\text{maximum possible electrical output per year}}$$

**Table 2** shows capacity factors for different types of power station.

**Table 2**

| Type of power station | Renewable energy source | Capacity factor |
|---|---|---|
| Coal | No | 0.41 |
| Natural gas | No | 0.48 |
| Nuclear | No | 0.66 |
| Solar thermal | Yes | 0.33 |
| Tidal | Yes | 0.26 |
| Wind turbine | Yes | 0.30 |

(i) Compare the capacity factors of the renewable power stations with those of the non-renewable power stations in **Table 2**.
Explain the reason for the difference between the capacity factors.

.....

.....

.....

.....

.....

.....

**(3)**

(ii) The capacity factor of a solar storage power station is higher than for all other renewable power stations.
Suggest **one** reason why.

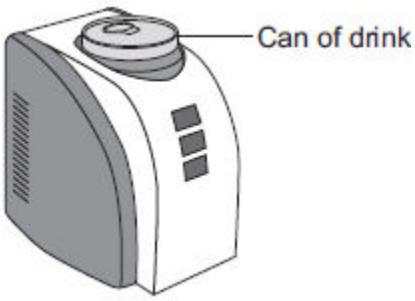
.....

.....

**(1)**
**(Total 14 marks)**

**17** A 'can-chiller' is used to make a can of drink colder.

The image below shows a can-chiller.




(a) The initial temperature of the liquid in the can was 25.0 °C.
The can-chiller decreased the temperature of the liquid to 20.0 °C.
The amount of energy transferred from the liquid was 6930 J.
The mass of liquid in the can was 0.330 kg.

Calculate the specific heat capacity of the liquid.

Give the unit.

.....

.....

.....

.....

Specific heat capacity = ..... unit .....

**(4)**

(b) Energy is transferred through the metal walls of the can of drink by conduction.
Explain how.

.....

.....

.....

.....

.....

.....

.....

.....

**(4)**

(c) The energy from the can of drink is transferred to the air around the can-chiller. A convection current is set up around the can-chiller. Explain how.

.....

.....

.....

.....

.....

.....

**(3)**

(d) The can-chiller has metal cooling fins that are designed to transfer energy quickly to the surroundings.

Give **two** features that would help the metal cooling fins to transfer energy quickly to the surroundings.

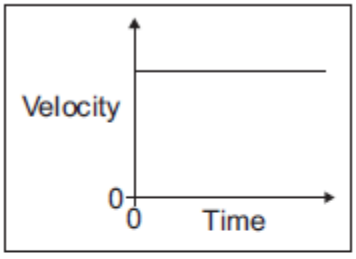
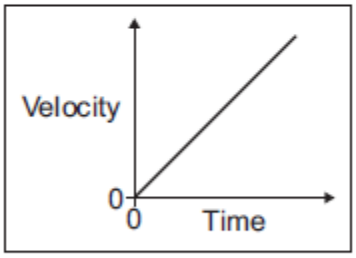
1.....

2.....

**(2)**

**(Total 13 marks)**

**18** (a) Draw **one** line from each velocity–time graph to the statement describing the motion shown by the graph.

| Velocity–time graph | Motion shown by graph |
|---|---|
|   | Constant acceleration |
| | Not moving |
|   | Constant deceleration |
| | Constant velocity |

**(2)**

(b) Use the correct answer from the box to complete the sentence.

| energy | momentum | speed |
|---|---|---|

The velocity of an object includes both the ..... of the object and the direction the object is moving.

**(1)**

(c) At the start of a race, a horse accelerates from a velocity of 0 m / s to a velocity of 9 m / s in 4 seconds.

(i) Calculate the acceleration of the horse.

.....

.....

Acceleration = ..... m / $s^2$

**(2)**

(ii) When the horse accelerates, what, if anything, happens to the air resistance acting against the horse?

Tick (✓) **one** box.

The air resistance decreases ☐

The air resistance is constant ☐

The air resistance increases ☐

**(1)**

(d) A horse and a pony walk across a field at the same constant speed.

The horse has 4000 joules of kinetic energy.

The pony is **half** the mass of the horse.

What is the kinetic energy of the pony?

Draw a ring around the correct answer

**2000 J** **4000 J** **8000 J**

Give a reason for your answer.

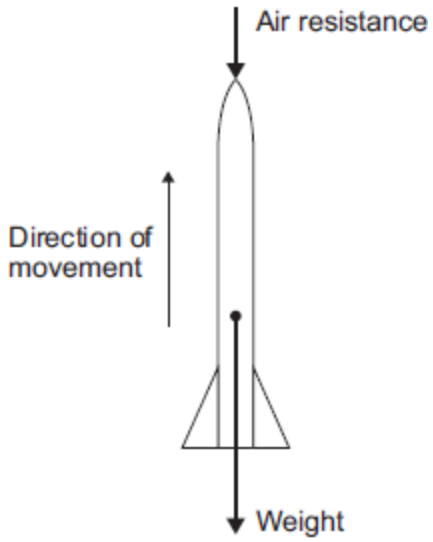
.....

.....

**(2)**
**(Total 8 marks)**

**19** (a) **Figure 1** shows the forces acting on a model air-powered rocket just after it has been launched vertically upwards.

**Figure 1**




(i) How does the velocity of the rocket change as the rocket moves **upwards**?

.....

Give a reason for your answer.

.....

.....

**(2)**

(ii) The velocity of the rocket is not the same as the speed of the rocket.

What is the difference between the velocity of an object and the speed of an object?

.....

.....

.....

**(1)**

(b) The speed of the rocket just after being launched is 12 m / s.
The mass of the rocket is 0.05 kg.

(i) Calculate the kinetic energy of the rocket just after being launched.

.....

.....

.....

Kinetic energy = ..... J

**(2)**

(ii) As the rocket moves upwards, it gains gravitational potential energy.

State the maximum gravitational potential energy gained by the rocket.

Ignore the effect of air resistance.

Maximum gravitational potential energy = ..... J

**(1)**

(iii) Calculate the maximum height the rocket will reach.

Ignore the effect of air resistance.

Gravitational field strength = 10 N / kg.

.....

.....

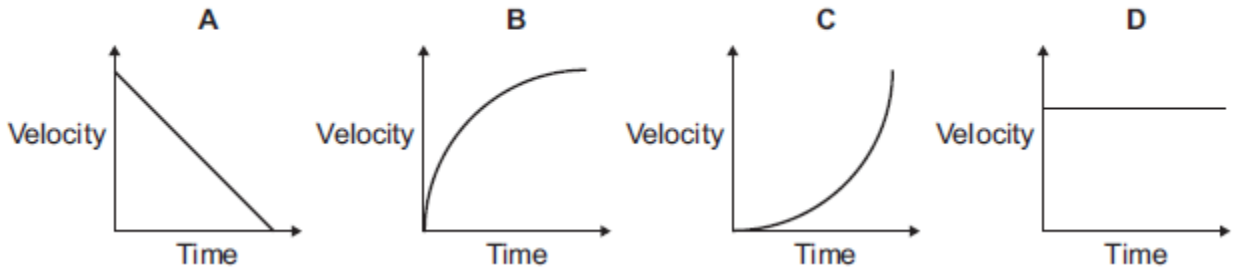
.....

Maximum height = ..... m

**(2)**

(iv) **Figure 2** shows four velocity−time graphs.

**Figure 2**




Taking air resistance into account, which graph, **A**, **B**, **C** or **D**, shows how the velocity of the rocket changes as it **falls** from the maximum height it reached until it just hits the ground?

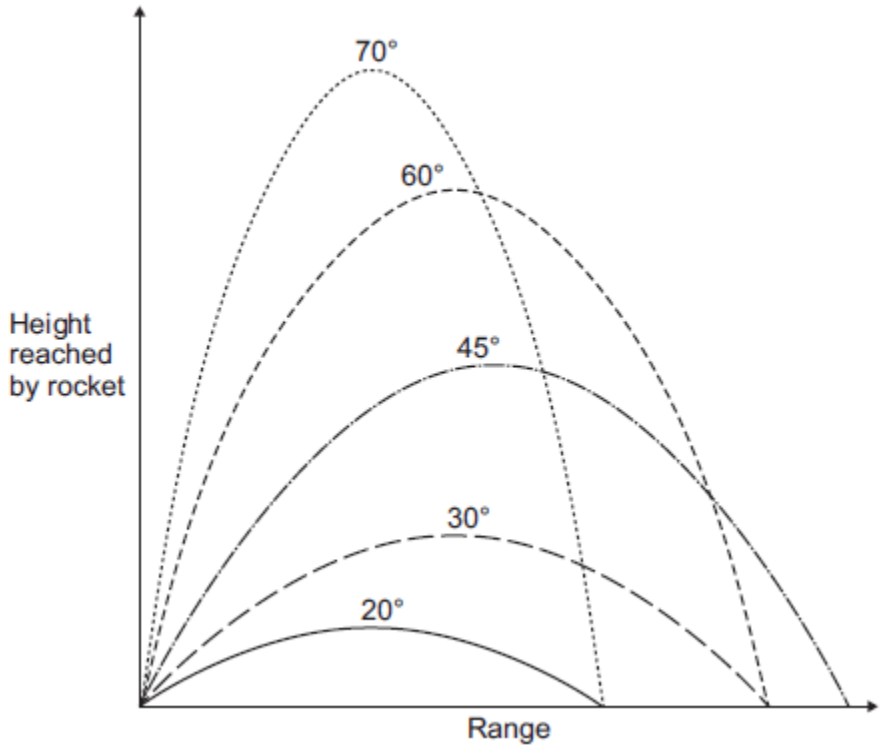
Write the correct answer in the box. ☐

**(1)**

(c) The rocket can be launched at different angles to the horizontal.
The horizontal distance the rocket travels is called the range.

**Figure 3** shows the paths taken by the rocket when launched at different angles.
Air resistance has been ignored.

**Figure 3**




What pattern links the angle at which the rocket is launched and the range of the rocket?

.....

.....

.....

.....

**(2)**
**(Total 11 marks)**

**20** A student finds some information about energy-saving light bulbs.

(a) A 30W light bulb uses 600J of electrical energy in a certain period of time. In that time, it produces 450 J of light energy. The rest of the energy is wasted.

(i) Calculate the energy wasted by the light bulb in this period of time.

.....

Wasted energy = ..... J

**(1)**

(ii) What happens to the energy wasted by the light bulb?

.....

.....

**(1)**

(iii) Calculate the efficiency of this light bulb.

.....

.....

Efficiency = .....

**(2)**

(iv) Calculate the period of time, in seconds, during which the 600 J is provided to the 30 W light bulb.

.....

.....

Time = ..... s

**(2)**

(b) A company that makes light bulbs provides information about some of their products.

The table shows some of this information.

| | **Power in watts** | **Lifetime in hours** | **Cost of bulb in £** |
|---|---|---|---|
| **Filament bulb** | 60 | 1250 | 2.00 |
| **LED bulb** | 12 | 50 000 | 16.00 |

(i) Suggest why it is important to confirm this information independently.

.....

**(1)**

(ii) A homeowner is thinking about replacing his filament bulbs with LED bulbs.

A 12 W LED bulb gives the same light output as a 60 W filament bulb.

Suggest reasons why the homeowner is likely to choose LED bulbs.

Use the information given in the table.

.....

.....

.....

.....

**(2)**

(iii) State **one** factor, other than efficiency, that is important when considering the choice of a bulb for lighting in the home.

.....

.....

**(1)**
**(Total 10 marks)**

**21** All objects emit and absorb infrared radiation.

(a) Use the correct answer from the box to complete each sentence.

| | | | |
|---|---|---|---|
| **dark matt** | **dark shiny** | **light matt** | **light shiny** |

The best emitters of infrared radiation have

..... surfaces.

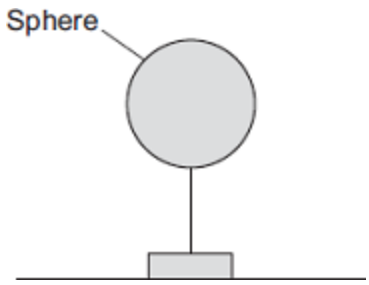
The worst emitters of infrared radiation have

..... surfaces.

**(2)**

(b) **Diagram 1** shows a sphere which is at a much higher temperature than its surroundings.

**Diagram 1**



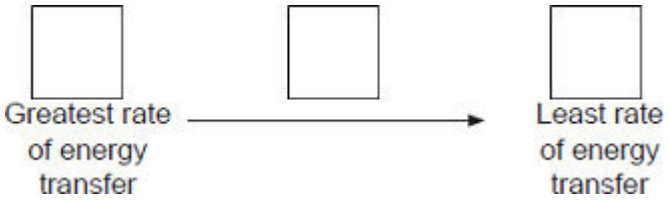

Energy is transferred from the sphere to the surroundings.

The table shows readings for the sphere in three different conditions, **A**, **B** and **C**.

| Condition | Temperature of sphere in °C | Temperature of surroundings in °C |
|---|---|---|
| **A** | 70 | 5 |
| **B** | 80 | 0 |
| **C** | 90 | 30 |

In each of the conditions, **A**, **B** and **C**, the sphere transfers energy to the surroundings at a different rate.

Put conditions **A**, **B** and **C** in the correct order.




Give a reason for your answer.

.....

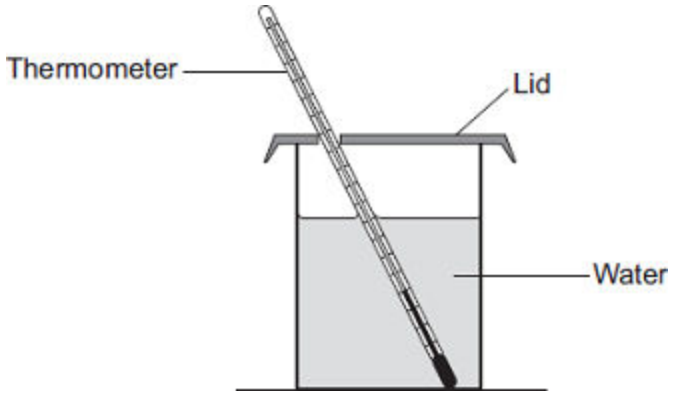
.....

**(2)**

(c) **Diagram 2** shows a can containing water.

A student investigates how quickly a can of water heats up when it is cooler than room temperature.

**Diagram 2**




The student has four cans, each made of the same material, with the following outer surfaces.

**dark matt** **dark shiny** **light matt** **light shiny**

The student times how long it takes the water in each can to reach room temperature.

Each can contains the same mass of water at the same starting temperature.

(i) Which can of water will reach room temperature the quickest?

Give a reason for your answer.

.....

.....

.....

.....

**(2)**

(ii) Apart from material of the can, mass of water and starting temperature, suggest **three** control variables for the student's investigation.

1 .....

.....

2 .....

.....

3 .....

.....

**(3)**

(d) The photographs show two different foxes.

**Fox A**

By Algkalv (Own work) [CC-BY-3.0], via Wikimedia Commons

**Fox B**

© EcoPic/iStock

Which fox is better adapted to survive cold conditions?

Give reasons for your answer.

.....

.....

.....

.....

.....

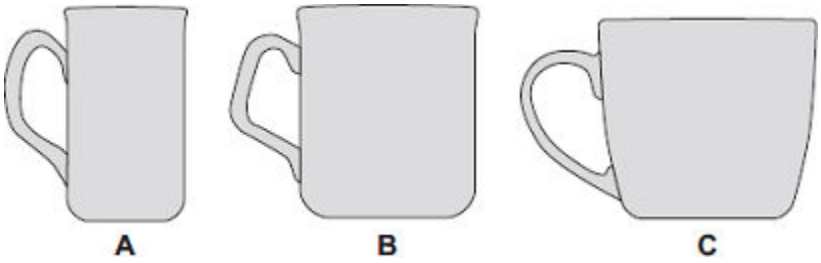
.....

.....

.....

**(3)**
**(Total 12 marks)**

**22** The diagram shows three cups **A**, **B** and **C**.




Energy is transferred from hot water in the cups to the surroundings.

(a) Use the correct answer from the box to complete each sentence.

| | | |
|---|---|---|
| **condensation** | **conduction** | **convection** |

Energy is transferred through the walls of the cup by ..... .

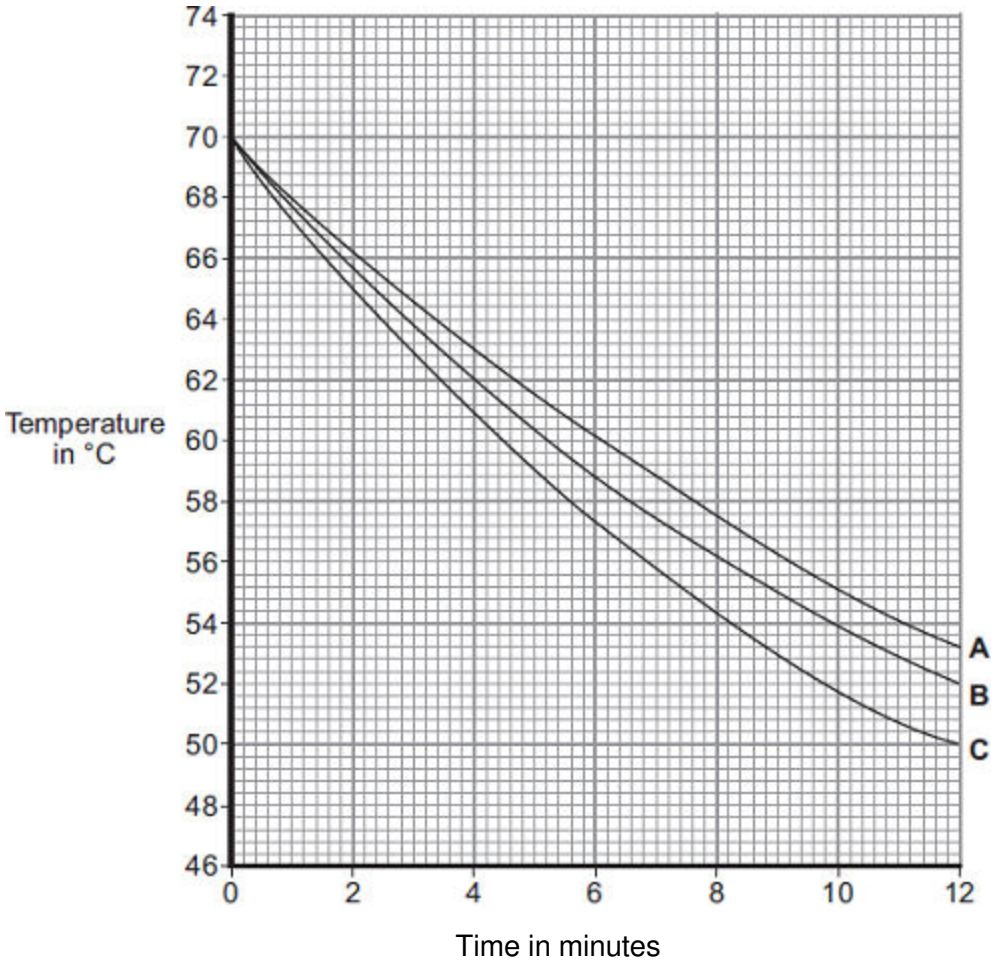
In the air around the cup, energy is transferred by ..... .

**(2)**

(b) Some students investigated how the rate of cooling of water in a cup depends on the surface area of the water in contact with the air.

They used cups **A**, **B** and **C**. They poured the same volume of hot water into each cup and recorded the temperature of the water at regular time intervals.

The results are shown on the graph.




(i) What was the starting temperature of the water for each cup?

Starting temperature = ..... °C

**(1)**

(ii) Calculate the temperature fall of the water in cup **B** in the first 9 minutes.

.....

Temperature fall = ..... °C

**(2)**

(iii) Which cup, **A**, **B** or **C**, has the greatest rate of cooling? ☐

Using the graph, give a reason for your answer.

.....

.....

**(2)**

(iv) The investigation was repeated using the bowl shown in the diagram.

The same starting temperature and volume of water were used.

Draw on the graph in part **(b)** another line to show the expected result.

**(1)**

(v) After 4 hours, the temperature of the water in each of the cups and the bowl was 20°C.

Suggest why the temperature does **not** fall below 20°C.

.....

**(1)**

(c) (i) The mass of water in each cup is 200 g.

Calculate the energy, in joules, transferred from the water in a cup when the temperature of the water falls by 8°C.

Specific heat capacity of water = 4200 J / kg°C.

.....

.....

.....

Energy transferred = ..... J

**(3)**

(ii) Explain, in terms of particles, how evaporation causes the cooling of water.

.....

.....

.....

.....

.....

.....

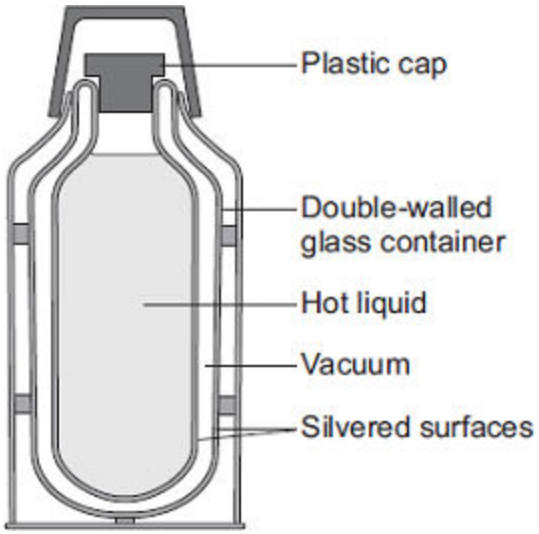
.....

.....

**(4)**
**(Total 16 marks)**

**23** (a) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

The diagram shows the structure of a vacuum flask.




A vacuum flask is designed to reduce the rate of energy transfer by heating processes.

Describe how the design of a vacuum flask keeps the liquid inside hot.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

**(6)**

(b) Arctic foxes live in a very cold environment.

© Purestock/Thinkstock

Arctic foxes have small ears.

How does the size of the ears help to keep the fox warm in a cold environment?

.....

.....

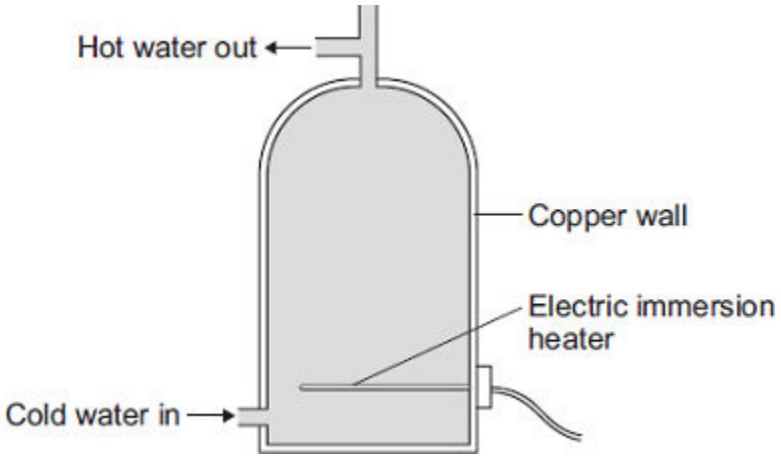
.....

.....

.....

**(2)**
**(Total 8 marks)**

**24** An electric immersion heater is used to heat the water in a domestic hot water tank.
When the immersion heater is switched on the water at the bottom of the tank gets hot.




(a) Complete the following sentence.

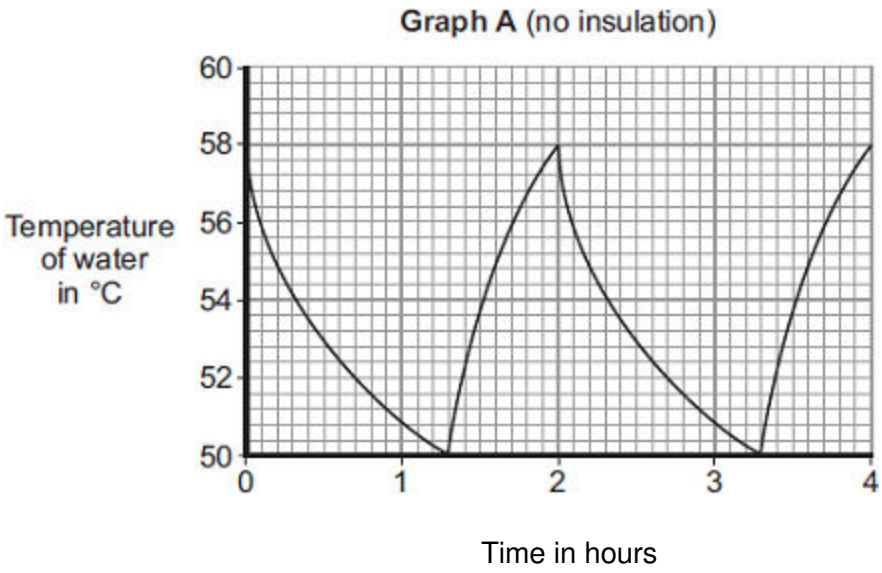
The main way the energy is transferred through the copper wall of the water tank is by the process of ..... .

**(1)**

(b) The immersion heater has a thermostat to control the water temperature.

When the temperature of the water inside the tank reaches 58°C the thermostat switches the heater off. The thermostat switches the heater back on when the temperature of the water falls to 50°C.

**Graph A** shows how the temperature of the water inside a hot water tank changes with time. The tank is **not** insulated.




(i) The temperature of the water falls at the fastest rate just after the heater switches off.

Explain why.

.....

.....

.....

.....

**(2)**

(ii) To heat the water in the tank from 50°C to 58°C the immersion heater transfers 4032 kJ of energy to the water.

Calculate the mass of water in the tank.

Specific heat capacity of water = 4200 J/kg°C

.....

.....

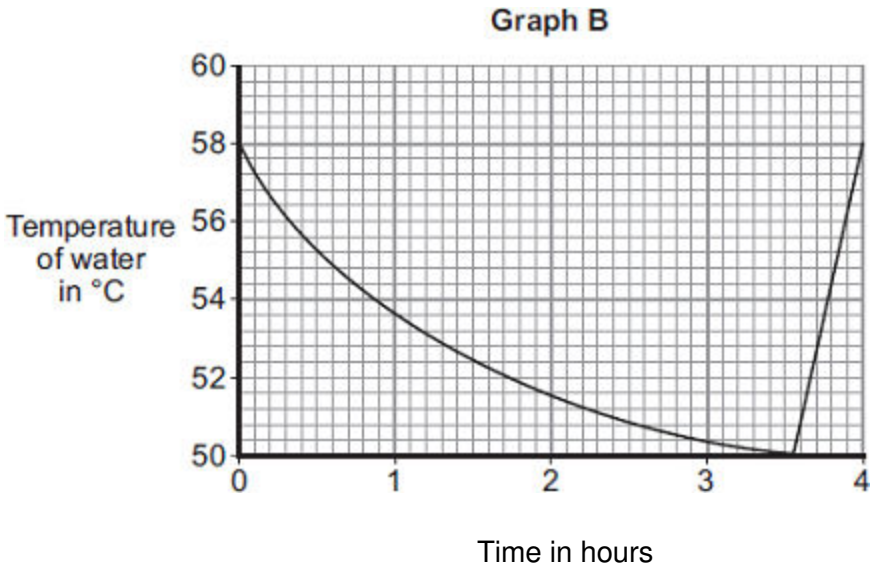
.....

Mass = ..... kg

**(3)**

(iii) An insulating jacket is fitted to the hot water tank.

**Graph B** shows how the temperature of the water inside the insulated hot water tank changes with time.




An insulating jacket only costs £12.

By comparing **Graph A** with **Graph B**, explain why fitting an insulating jacket to a hot water tank saves money.

.....

.....

.....

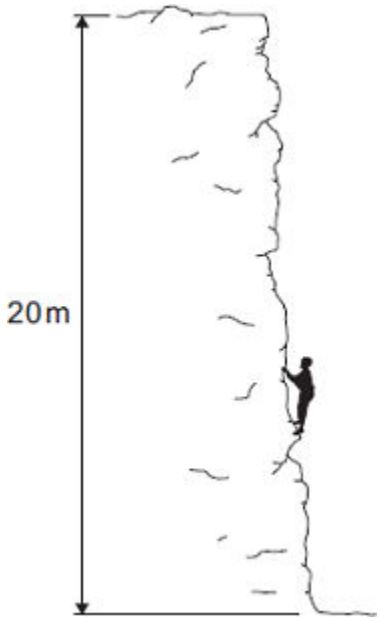
.....

.....

.....

**(3)**
**(Total 9 marks)**

**25** The diagram shows a climber part way up a cliff.




(a) Complete the sentence.

When the climber moves up the cliff, the climber

gains gravitational ..... energy.

**(1)**

(b) The climber weighs 660 N.

(i) Calculate the work the climber must do against gravity, to climb to the top of the cliff.

.....

.....

Work done = ..... J

**(2)**

(ii) It takes the climber 800 seconds to climb to the top of the cliff.
During this time the energy transferred to the climber equals the work done by the climber.

Calculate the power of the climber during the climb.

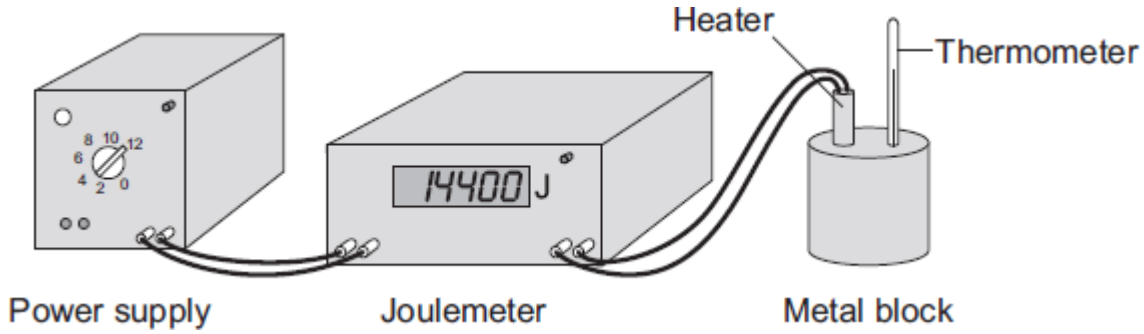
.....

.....

Power = ..... W

**(2)**
**(Total 5 marks)**

**26** A student used an electric heater to heat a metal block. The student measured the energy input to the heater with a joulemeter.




Before starting the experiment, the student reset the joulemeter to zero. The student switched the power supply on for exactly 10 minutes. During this time, the reading on the joulemeter increased to 14 400.

(a) (i) Calculate the energy transferred each second from the power supply to the heater.

Show clearly how you work out your answer.

.....

.....

Energy transferred each second = ..... J/s

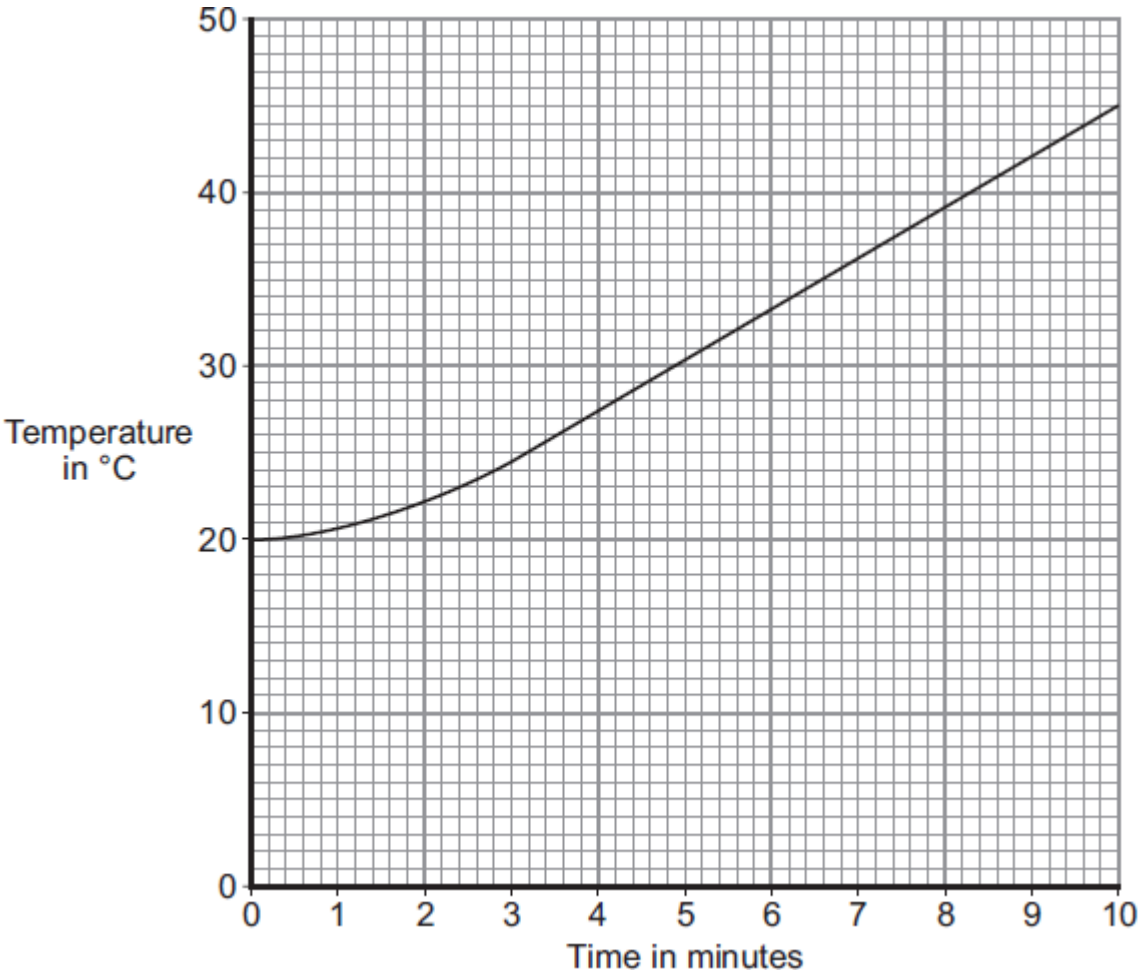
**(2)**

(ii) What is the power of the heater?

.....

**(1)**

(b) The student measured the temperature of the metal block every minute. The data obtained by the student is displayed in the graph.




(i) What range of temperatures did the student measure?

From ..... °C to ..... °C

**(1)**

(ii) Before starting the experiment, the student had calculated that the temperature of the block would go up by 36 °C.

The student's data shows a smaller increase.

Which **one** of the following statements gives the most likely reason for this?

Put a tick (✓) in the box next to your answer.

The student does not read the thermometer accurately. ☐

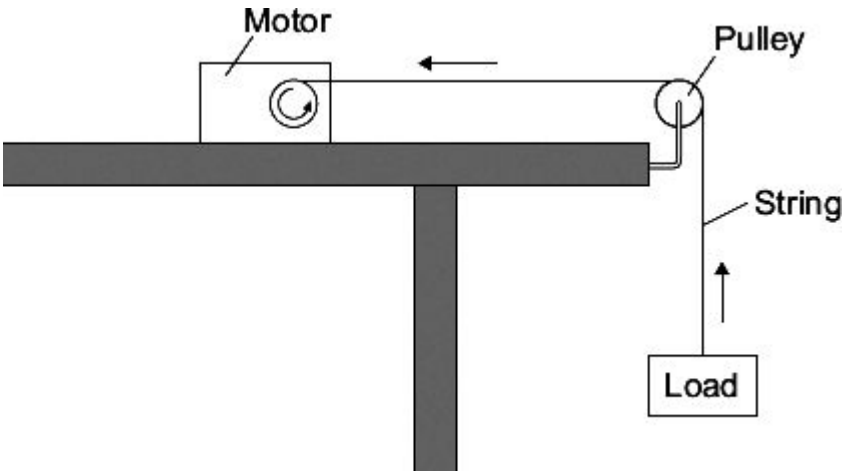
The block transfers energy to the surroundings. ☐

The power supply is not connected correctly to the joulemeter. ☐

**(1)**

**(Total 5 marks)**

**27** A student uses an electric motor to lift a load.




In the motor, the electrical energy is transferred into other types of energy. Some of this energy is useful and the rest of the energy is wasted.

(a) (i) Name the useful energy output from the electric motor.

.....

**(1)**

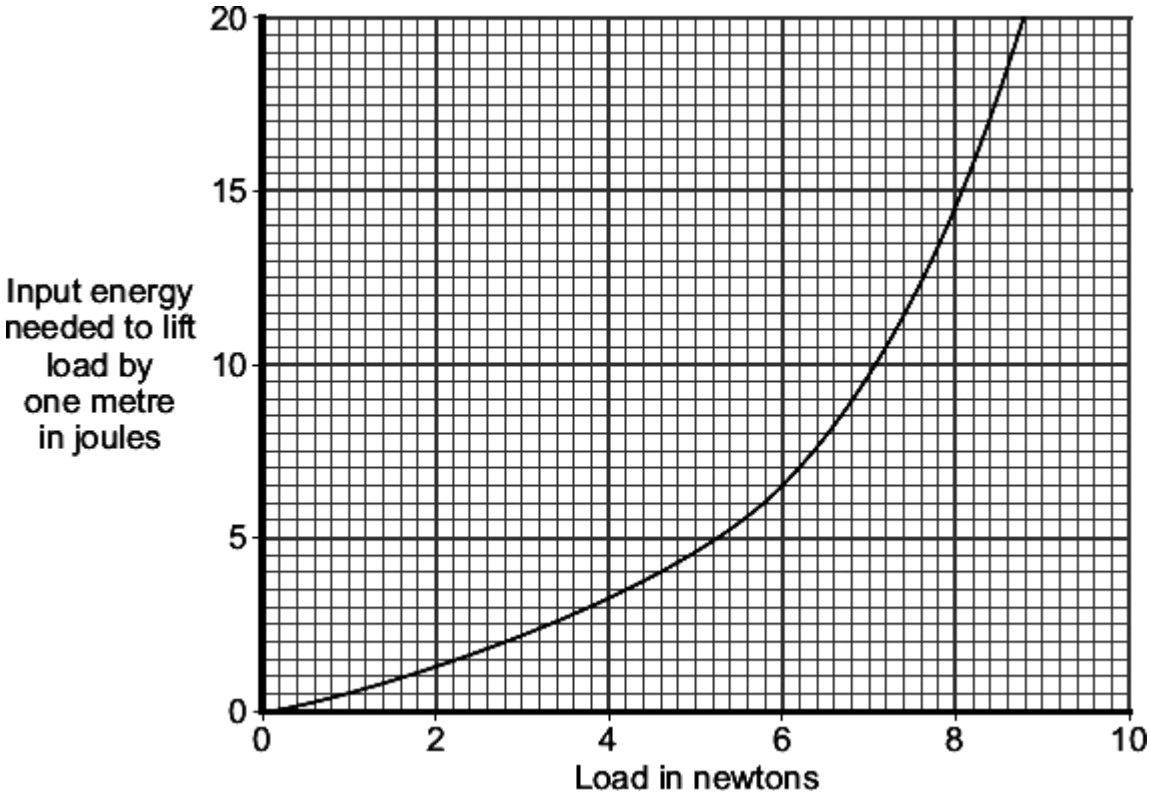
(ii) What eventually happens to the wasted energy?

.....

.....

**(1)**

(b) The graph shows the input energy the motor needs to lift different loads by one metre.




What can you conclude from the graph about the relationship between the load lifted and the input energy needed?

.....

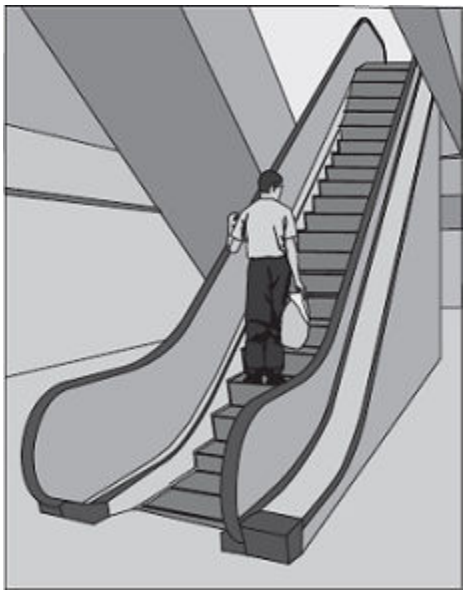
.....

.....

.....

**(2)**

(c) A shop uses escalators to lift customers to different floor levels. The escalators use electric motors. When the shop is not busy some escalators are turned off. A sign tells the customers that the escalators are turned off to save energy.



(i) Each escalator has one motor with an average power of 4000 W. The motor is turned on for an average of 8 hours each day, 6 days each week. Electricity costs 15 pence per kilowatt-hour.

Calculate the cost of the electricity used in an average week to run **one** escalator.

Show clearly how you work out your answer.

.....

.....

.....

.....

Cost = ..... pence

**(3)**

(ii) Give **one** environmental advantage to turning off electrical appliances when they are not being used.

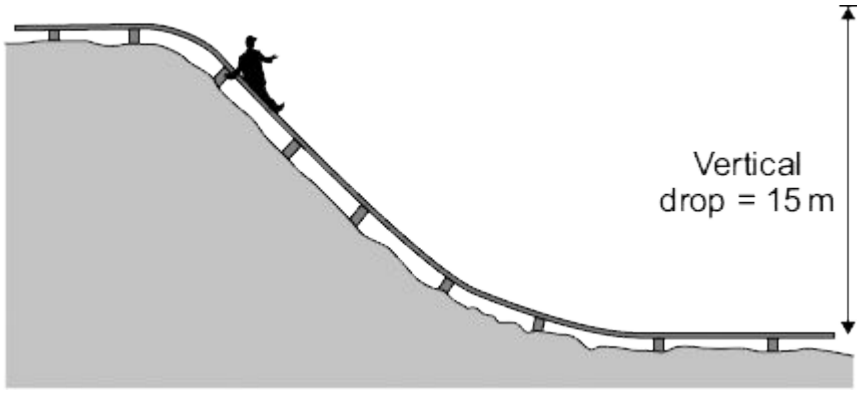
.....

.....

**(1)**

**(Total 8 marks)**

**28** The miners working in a salt mine use smooth wooden slides to move quickly from one level to another.




(a) A miner of mass 90 kg travels down the slide.

Calculate the change in gravitational potential energy of the miner when he moves 15 m vertically downwards.

| gravitational field strength = 10 N/kg |
|---|

Show clearly how you work out your answer.

.....

.....

Change in gravitational potential energy = ..... J

**(2)**

(b) Calculate the **maximum** possible speed that the miner could reach at the bottom of the slide.

Show clearly how you work out your answer.

Give your answer to an appropriate number of significant figures.

.....

.....

.....

.....

Maximum possible speed = ..... m/s

**(3)**

(c) The speed of the miner at the bottom of the slide is much less than the calculated maximum possible speed.

Explain why.

.....

.....

.....

.....

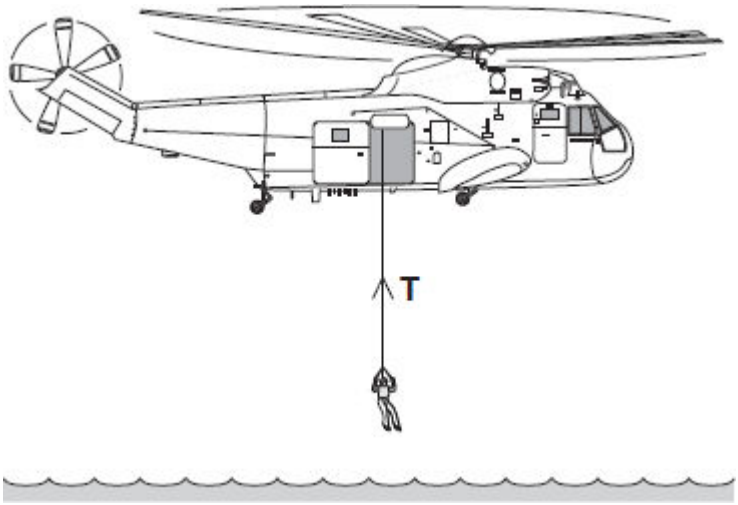
.....

.....

.....

**(3)**
**(Total 8 marks)**

**29** The diagram shows a helicopter being used to rescue a person from the sea.




(a) (i) The mass of the rescued person is 72 kg.

Use the equation in the box to calculate the weight of the rescued person.

| weight = mass × gravitational field strength |
|---|

gravitational field strength = 10 N/kg

Show clearly how you work out your answer.

.....

.....

Weight = ..... N

**(2)**

(ii) An electric motor is used to lift the person up to the helicopter.
The motor lifts the person at a constant speed.

State the size of the force, **T**, in the cable.

Force **T** = ..... N

**(1)**

(b) To lift the person up to the helicopter, the electric motor transformed 21 600 joules of energy usefully.

(i) Use a form of energy from the box to complete the following sentence.

| | | |
|---|---|---|
| gravitational potential | heat | sound |

The electric motor transforms electrical energy to kinetic energy. The kinetic energy is then transformed into useful ..... energy.

**(1)**

(ii) It takes 50 seconds for the electric motor to lift the person up to the helicopter.

Use the equation in the box to calculate the power of the electric motor.

$$\text{power} = \frac{\text{energy transformed}}{\text{time}}$$

Show clearly how you work out your answer and give the unit.

Choose the unit from the list below.

**coulomb (C)** **hertz (Hz)** **watt (W)**

.....

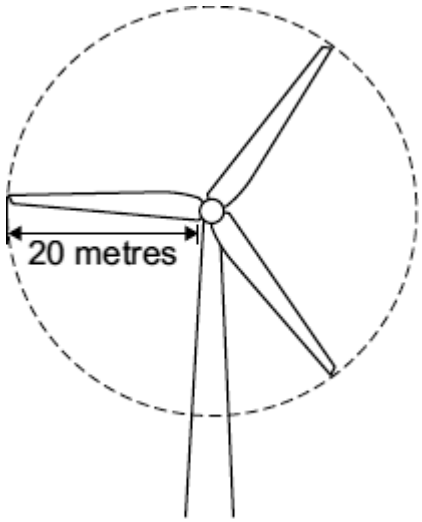
.....

Power = .....

**(3)**

**(Total 7 marks)**

**30** The diagram shows a wind turbine.




(a) The blades of the turbine are 20 metres long. On average, 15 000 kg of air, moving at a speed of 12 m/s, hit the blades every second.

Calculate the kinetic energy of the air hitting the blades every second.

Show clearly how you work out your answer.

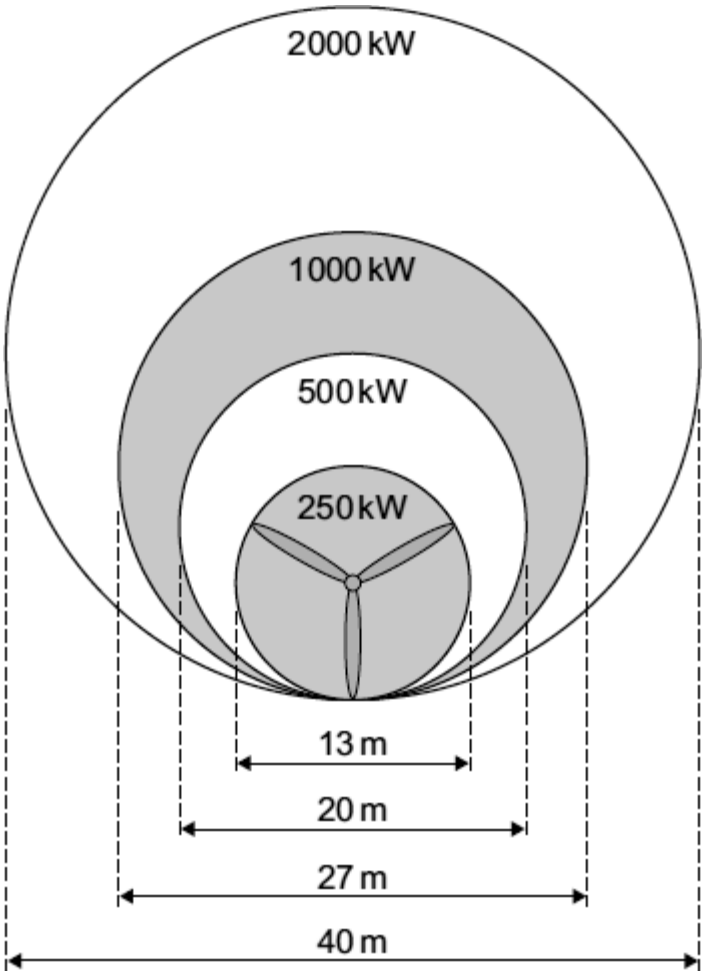
.....

.....

Kinetic energy = ..... J

**(2)**

(b) Part of the kinetic energy of the wind is transformed into electrical energy.
The diagram shows that, for the same wind speed, the power output of a turbine, in kilowatts, depends on the length of the turbine blades.



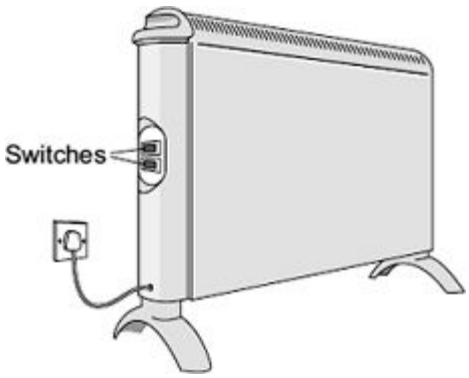

Give a reason why doubling the diameter of the blades more than doubles the power output of a turbine.

.....

.....

**(1)**
**(Total 3 marks)**

**31** (a) The diagram shows two switches on a room heater. The heater has three power settings. The power produced by two of the settings is given in the table.




| Setting | Power in watts |
|---|---|
| Low | 700 |
| Medium | 1400 |
| High | |

(i) When both switches are on, the heater works at the high power setting.

What is the power of the heater, in kilowatts, when it is switched to the **high** power setting?

.....

Power = ..... kilowatts

**(1)**

(ii) The heater is used on the **high** power setting. It is switched on for 1½ hours.

Calculate the energy transferred from the mains to the heater in 1½ hours.

Show clearly how you work out your answer and give the unit.

.....

.....

.....

Energy transferred = .....

**(3)**

(iii) This type of heater is a very efficient device.

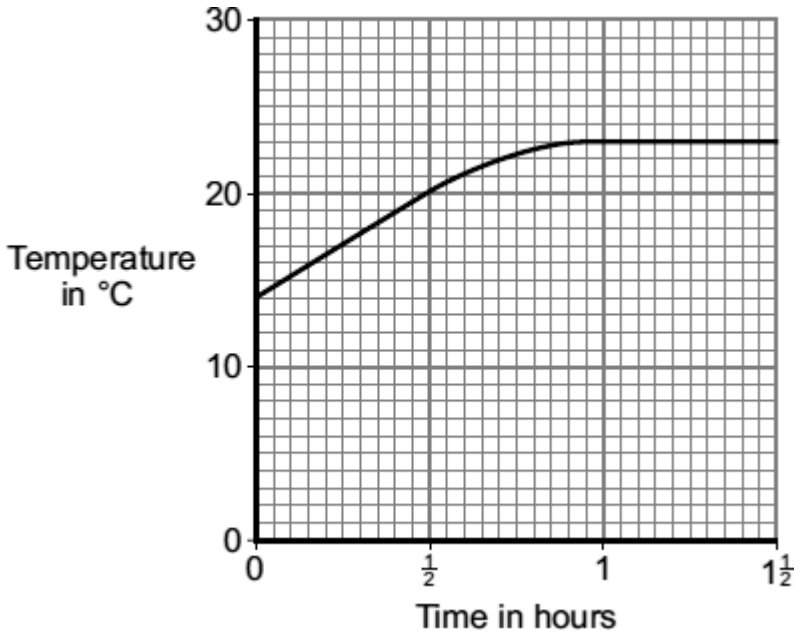
What is meant by a device being very efficient?

.....

.....

**(1)**

(b) The graph shows how the temperature of a room changes during the 1½ hours that the heater is used.




After 1 hour, the temperature of the room has become constant, even though the heater is still switched on.

Explain why.

.....

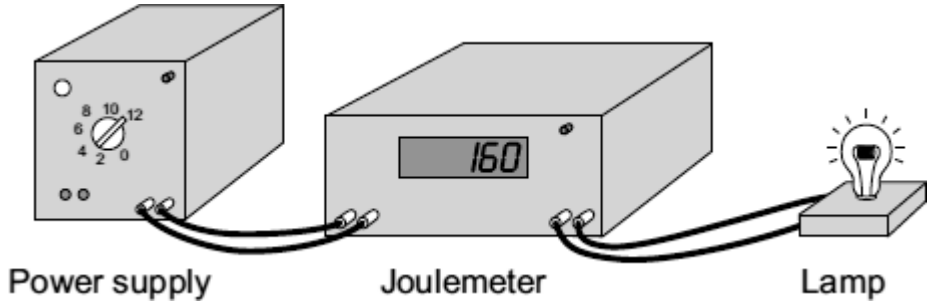
.....

.....

.....

**(2)**
**(Total 7 marks)**

**32** A student used a joulemeter to measure the energy transformed by a lamp.




The student set the joulemeter to zero, and then switched on the power supply.

After 120 seconds (2 minutes), the reading on the joulemeter had increased to 2880.

(a) In the space below, draw the circuit symbol used to represent a lamp.

**(1)**

(b) (i) Use the equation in the box to calculate the power of the lamp.

$$\text{power} = \frac{\text{energy transformed}}{\text{time}}$$

Show clearly how you work out your answer.

.....

.....

Power = .....

**(2)**

(ii) Which **one** of the following is the unit of power?

Draw a ring around your answer.

**joule** **newton** **watt**

**(1)**

(c) Complete the following sentence using one of the phrases from the box.

| larger than | the same as | smaller than |
|---|---|---|

If the lamp was left switched on for 10 minutes, the amount of energy transformed would be ..... the amount of energy transformed in 2 minutes.

**(1)**
**(Total 5 marks)**

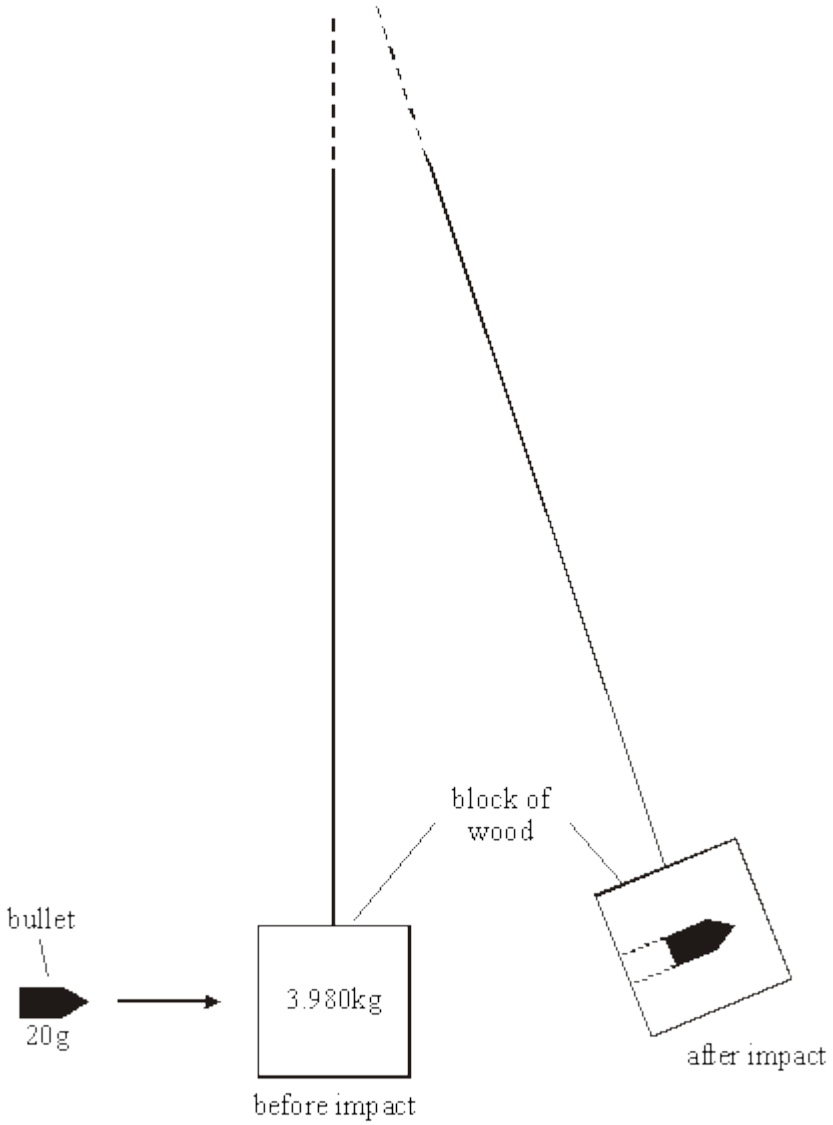
**33** (a) When an object is moving it is said to have momentum.
Define momentum.

.....

.....

**(1)**

(b) The diagram below shows one way of measuring the velocity of a bullet.




A bullet is fired into a block of wood suspended by a long thread.
The bullet stops in the wooden block.
The impact of the bullet makes the block swing.
The velocity of the wooden block can be calculated from the distance it swings.

In one such experiment the block of wood and bullet had a velocity of 2 m/s **immediately after** impact. The mass of the bullet was 20 g and the mass of the wooden block 3.980 kg.

(i) Calculate the combined mass of the block of wood and bullet.

..... Mass .....

**(1)**

(ii) Calculate the momentum of the block of wood and bullet **immediately after** impact.

.....

.....

.....

.....

…..... Momentum .....

**(3)**

(iii) State the momentum of the bullet **immediately before** impact.

.....

**(1)**

(iv) Calculate the velocity of the bullet **before** impact.

.....

.....

.....

……..... Velocity ..... m/s

**(3)**

(v) Calculate the kinetic energy of the block of wood and bullet **immediately after** impact.

.....

.....

.....

……..... Kinetic energy ..... J

**(3)**

(vi) The kinetic energy of the bullet before the impact was 1600 joules. This is much greater than the kinetic energy of the bullet and block just after the impact. What has happened to the rest of the energy?

.....

.....

.....

.....

**(1)**

**(Total 13 marks)**

**34** When you transfer *energy* to a shopping trolley, the amount of *work done* depends on the *force* used and the *distance moved*.


Complete the table by using the correct units from the box.

| **joule (J)** | **metre (m)** | **newton (N)** |
|---|---|---|

The first one has been done for you.

| **Quantity** | **Unit** |
|---|---|
| energy (transferred) | joule |
| force | |
| distance (moved) | |
| work done | |

**(Total 2 marks)**

**35** When a gun is fired, a very large force acts on the bullet for a very short time.

The change in momentum of the bullet is given by the following relationship:

force (N) × time(s) = change in momentum (kg m/s)

(a) An average force of 4000 newton acts for 0.01 seconds on a bullet of mass 50g.

Calculate the speed of the bullet. (*Show your working.*)

.....

.....

.....

Answer ..... m/s

**(4)**

(b) The bullet is fired horizontally. In the short time it takes for the bullet to reach its target, its horizontal speed has fallen to 80% of its initial speed.

(i) Explain why the speed of the bullet decreases so quickly.

.....

.....

**(2)**

(ii) Calculate the percentage of its original kinetic energy the bullet still has when it reaches its target.

*(Show your working.)*

.....

.....

.....

.....

**(4)**
**(Total 10 marks)**