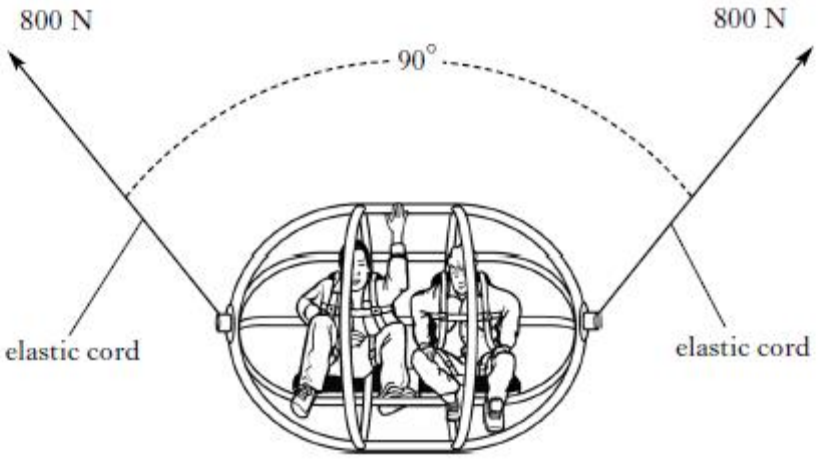
Velocity & Displacment

Marks

22. A fairground ride uses a giant catapult to launch people upwards using elastic cords.



(*a*) Each cord applies a force of 800 N and the cords are at 90° as shown. Using a scale diagram, or otherwise, find the size of the resultant of these two forces. 2

(*b*) The cage is now pulled further down before release. The cords provide an upward resultant force of 2700 N. The cage and its occupants have a total mass of 180 kg.

(i) Calculate the weight of the cage and occupants. 2

(ii) Calculate the acceleration of the cage and occupants when released. 3

(7)

21. A plane of mass 750 kg is at rest on a runway. The engine applies a force of 4·50 kN.

(*a*) Calculate the magnitude of the acceleration of the plane assuming there are no other forces acting on the plane at this point. 2

(*b*) The required speed for take-off is 54 m/s.

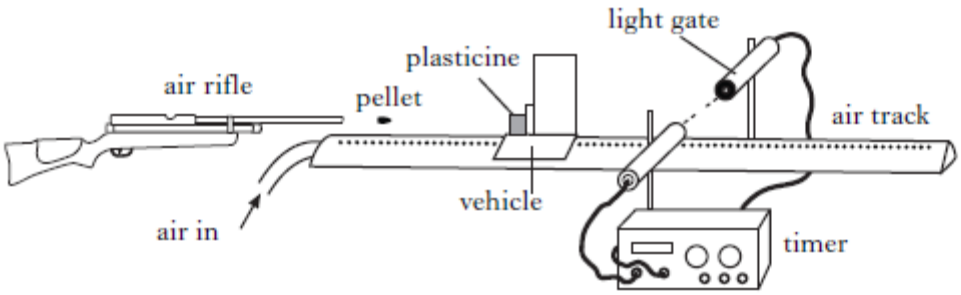
Calculate the time it takes to reach this speed assuming the acceleration is constant. 2

(*c*) In practice the acceleration is not constant. Give a reason for this. 1

(5)

Marks

23. The following apparatus is used to determine the speed of a pellet as it leaves an air rifle. The air rifle fires a pellet into the plasticine, causing the vehicle to move.

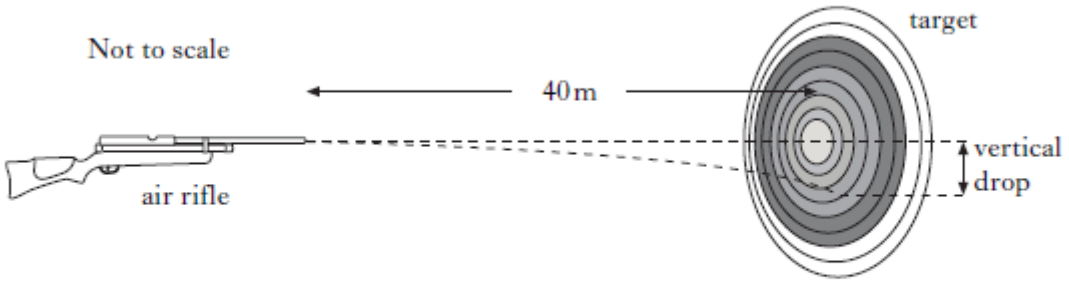


(*a*) Describe how the apparatus is used to determine the speed of the vehicle.

Your description must include:

- the measurements made
- any necessary calculations. **2**

(*c*) At a firing range a pellet is fired horizontally at a target 40 m away. It takes 0·20 s to reach the target.



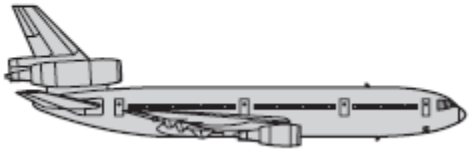
(i) Calculate the **vertical** velocity of the pellet on reaching the target. **2**

(ii) Calculate the vertical drop. **2**

(8)

Marks

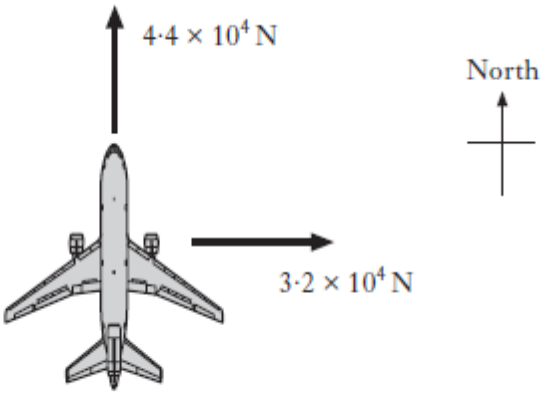
23. An aircraft is flying horizontally at a constant speed.



(*a*) The aircraft and passengers have a total mass of 50 000 kg. Calculate the total weight. **2**

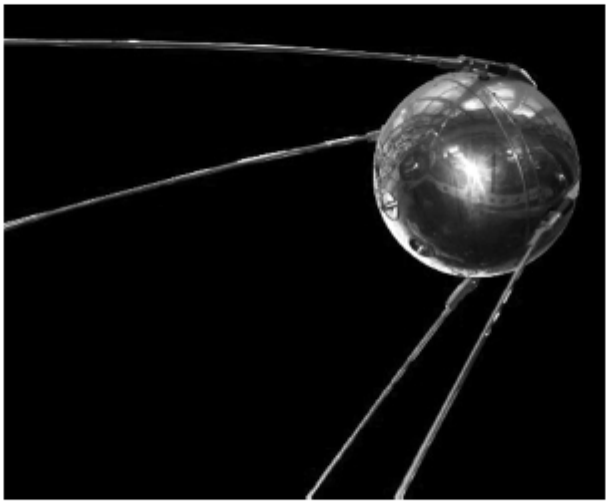
(*b*) State the magnitude of the upward force acting on the aircraft. **1**

(*c*) During the flight, the aircraft's engines produce a force of $4{\cdot}4 \times 10^4$ N due North. The aircraft encounters a crosswind, blowing from west to east, which exerts a force of $3{\cdot}2 \times 10^4$ N.



Calculate the resultant force on the aircraft. **3**

21. Sputnik 1, the first man-made satellite, was launched in 1957. It orbited the Earth at a speed of 8300 m/s and had a mass of 84 kg.



(*a*) (i) Sputnik 1 orbited Earth in 100 minutes.

Calculate the distance it travelled in this time. **2**

(ii) Although Sputnik 1 travelled at a constant speed in a circular orbit, it accelerated continuously.

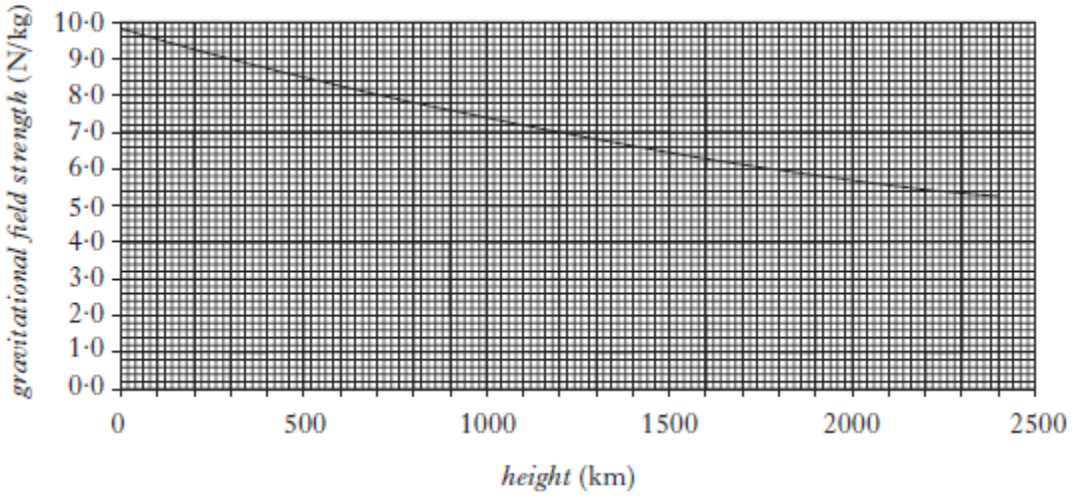
Explain this statement. **2**

(*b*) Sputnik 1 transmitted radio signals a distance of 800 km to the surface of the Earth.

Calculate the time taken for the signals to reach the Earth's surface. **2**

21. (continued) *Marks*

(*c*) The graph shows how gravitational field strength varies with height above the surface of the Earth.



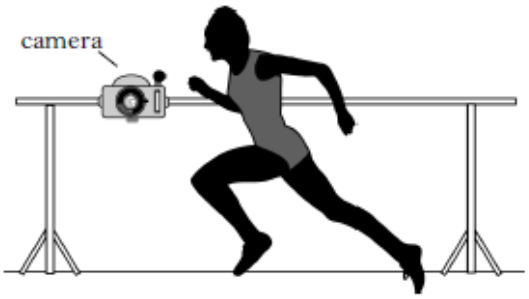
(i) Define the term **gravitational field strength**. **1**

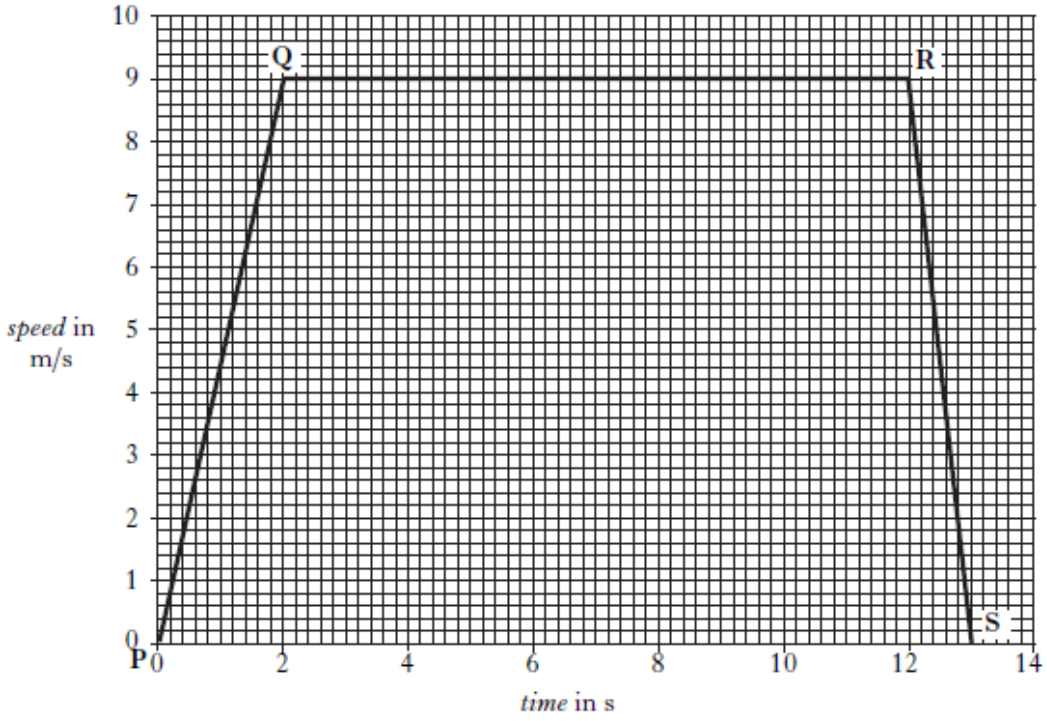
(ii) What is the value of the gravitational field strength at a height of 800 km? **1**

(iii) Calculate the weight of Sputnik 1 at this height. **2**

(10)

21. Athletes in a race are recorded by a TV camera which runs on rails beside the track.





The graph shows the speed of the camera during the race.

(*a*) Calculate the acceleration of the camera between **P** and **Q**. 2

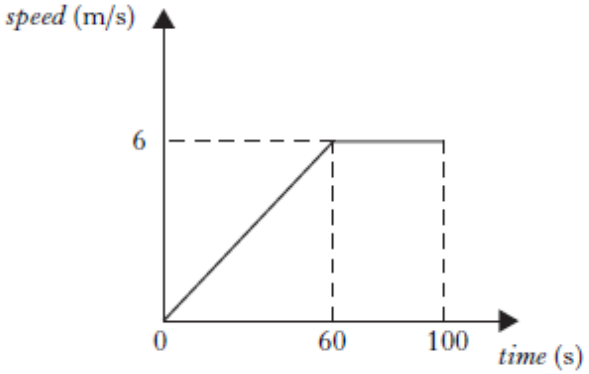
(*b*) The mass of the camera is 15 kg.

Calculate the unbalanced force needed to produce the acceleration between **P** and **Q**. 2

(*c*) How far does the camera travel in the 13 s? 2

21. A balloon of mass 400 kg rises vertically from the ground.

The graph shows how the vertical speed of the balloon changes during the first 100 s of its upward flight.



(*a*) Calculate the acceleration of the balloon during the first 60 s. **2**

(*b*) Calculate the distance travelled by the balloon in 100 s. **2**

(*c*) Calculate the average speed of the balloon during the first 100 s. **2**

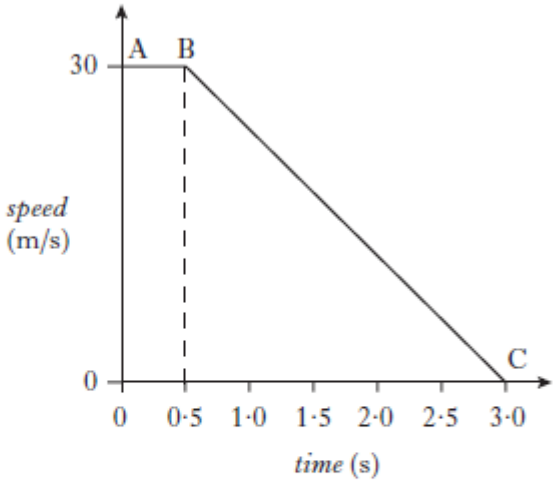
(*d*) Calculate the weight of the balloon. **2**

(*e*) Calculate the total upward force acting on the balloon during the first 60 s of its flight. **3**

(11)

Marks

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

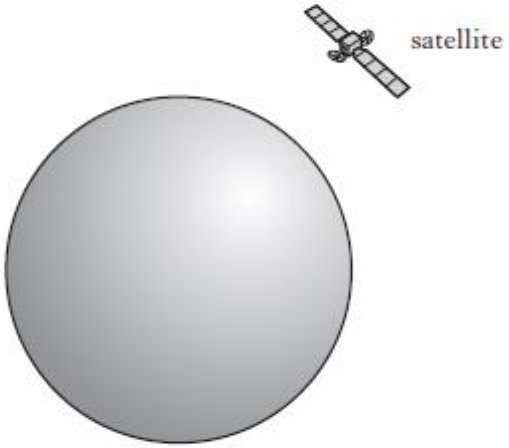
(*c*) State the work done in bringing the car to a halt between B and C. 1

(*d*) Show by calculation that the magnitude of the unbalanced force required to bring the car to a halt between B and C is 8400 N. 2

(7)

Marks

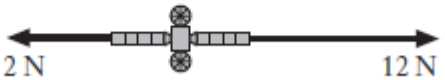
22. A satellite moves in a circular orbit around a planet. The satellite travels at a constant speed whilst accelerating.



(*a*) (i) Define the term *acceleration*. **1**

(ii) Explain how the satellite can be accelerating when it is travelling at a constant speed. **1**

(*b*) At one particular point in its orbit the satellite fires two rockets. The forces exerted on the satellite by these rockets are shown on the diagram.



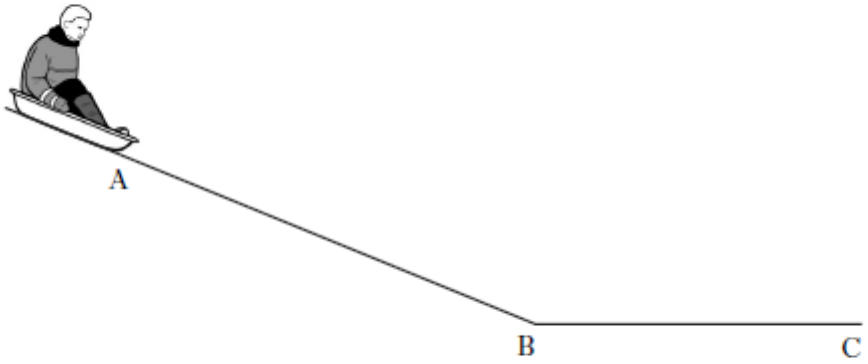
The satellite has a mass of 50 kg. Calculate the resultant acceleration due to these forces. **3**

(5)

Newton's Laws

Marks

22. A child sledges down a hill.



The sledge and child are released from rest at point A. They reach a speed of 3 m/s at point B.

(*a*) The sledge and child take 5 s to reach point B.

Calculate the acceleration. 2

(*b*) The sledge and child have a combined mass of 40 kg.

Calculate the unbalanced force acting on them. 2

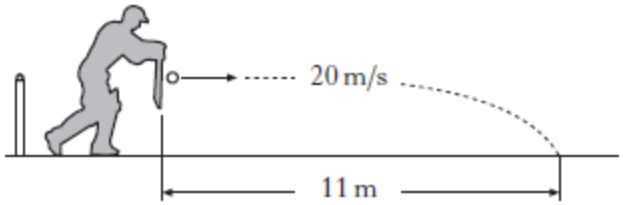
(*c*) After the sledge and child pass point B, they slow down, coming to a halt at point C.

Explain this motion in terms of forces. 2

(6)

Projectile Motion

21. A cricketer strikes a ball. The ball leaves the bat horizontally at 20 m/s. It hits the ground at a distance of 11 m from the point where it was struck.



Assume that air resistance is negligible.

(*a*) Calculate the time of flight of the ball. **2**

(*b*) Calculate the vertical speed of the ball as it reaches the ground. **2**

(*c*) Sketch a graph of vertical speed against time for the ball. Numerical values are required on both axes. **2**

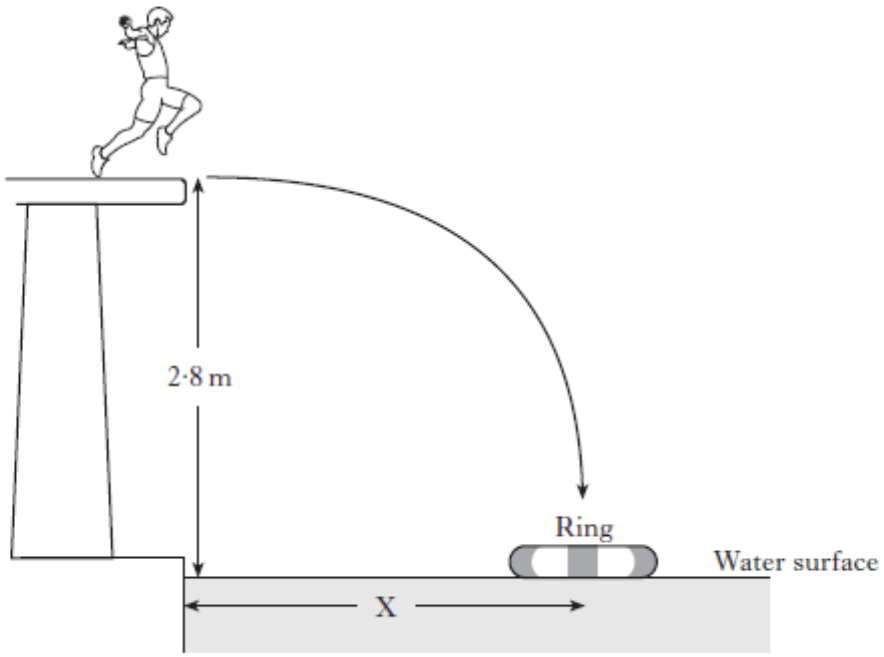
(*d*) Calculate the vertical distance travelled by the ball during its flight. **2**

(8)

Marks

23. In a TV game show contestants are challenged to run off a horizontal platform and land in a rubber ring floating in a swimming pool.

The platform is 2·8 m above the water surface.



(*a*) A contestant has a mass of 60 kg.

He runs off the platform with a horizontal velocity of 2 m/s. He takes 0·75 s to reach the water surface in the centre of the ring.

(i) Calculate the horizontal distance X from the poolside to the centre of the ring. **2**

(ii) Calculate the vertical velocity of the contestant as he reaches the water surface. **2**

(*b*) Another contestant has a mass of 80 kg.

Will she need to run faster, slower or at the same horizontal speed as the first contestant to land in the ring?

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

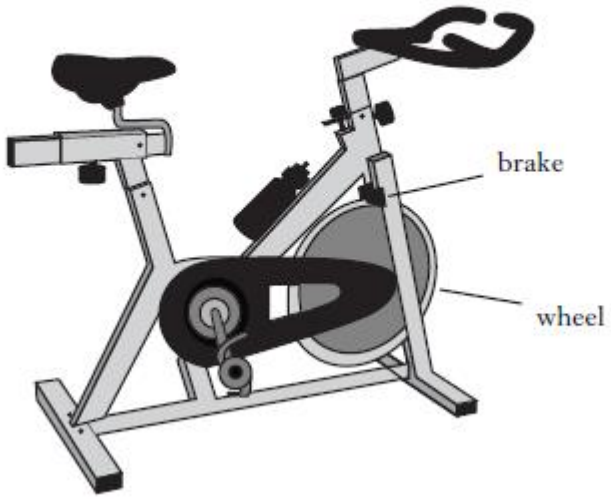
(6)

Space Exploration

Cosmology

Marks

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**

(*b*) The wheel is a solid aluminium disc of mass 12·0 kg.

(i) All the work done by friction is converted to heat in the disc.

Calculate the temperature rise after 500 turns. **2**

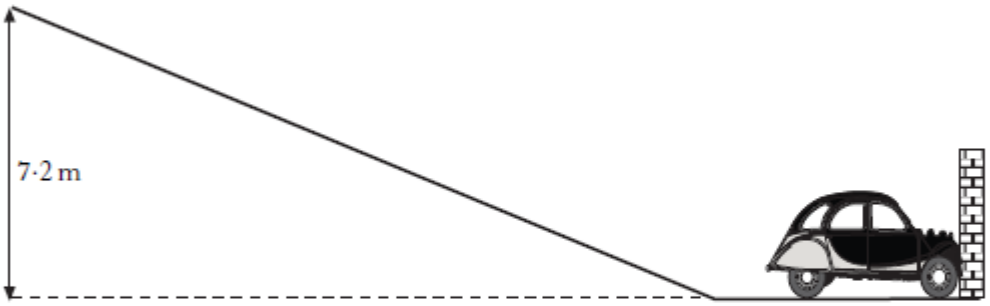
(ii) Explain why the actual temperature rise of the disc is less than calculated in (*b*) (i). **1**

(8)

Marks

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**

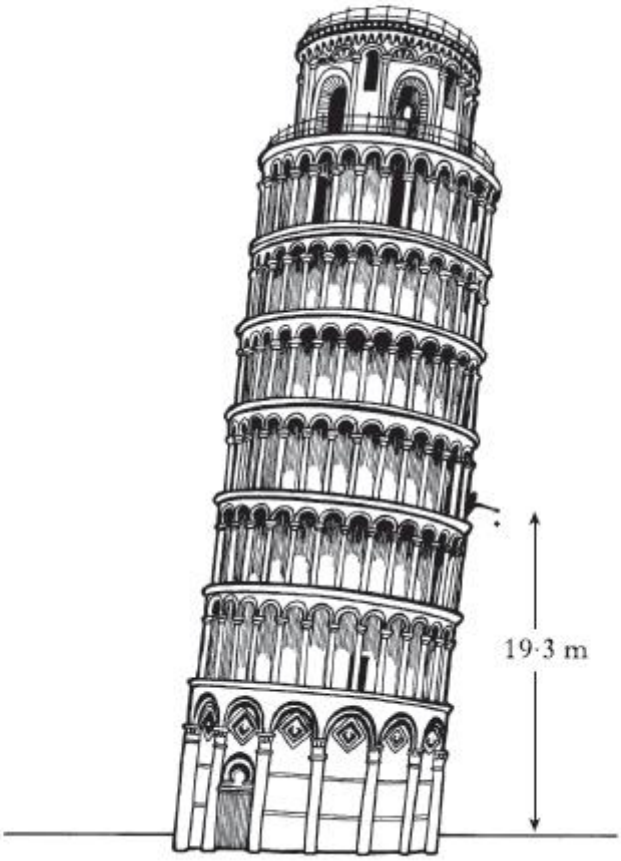
(*b*) (i) State the value of the kinetic energy of the car at the bottom of the slope, assuming no energy losses. **1**

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

(5)

Marks

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**

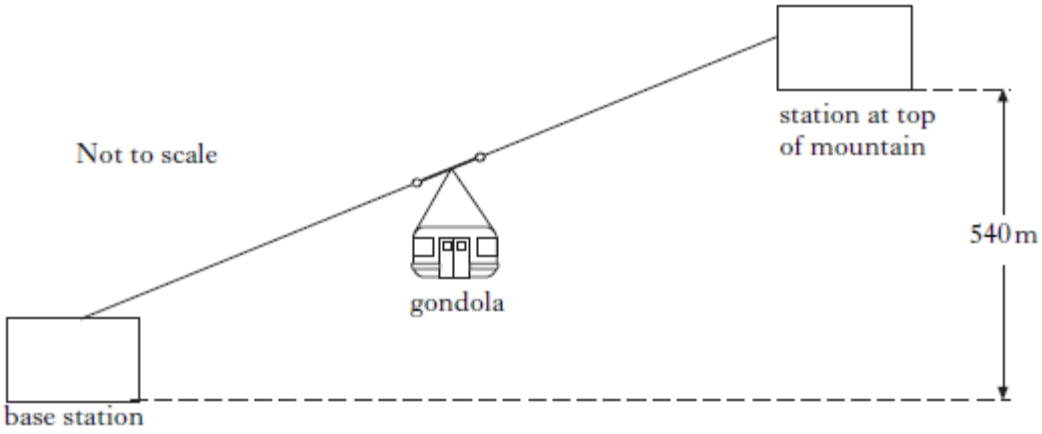
(iii) Is the actual temperature change of the ball greater than, the same as or less than the value calculated in part (*a*)(ii)?

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)

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**

(*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.

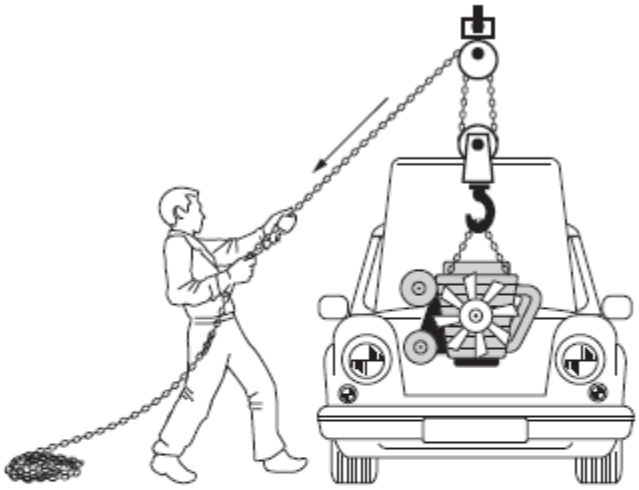
(i) Calculate the maximum current in the motor. **2**

(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)

Marks

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**

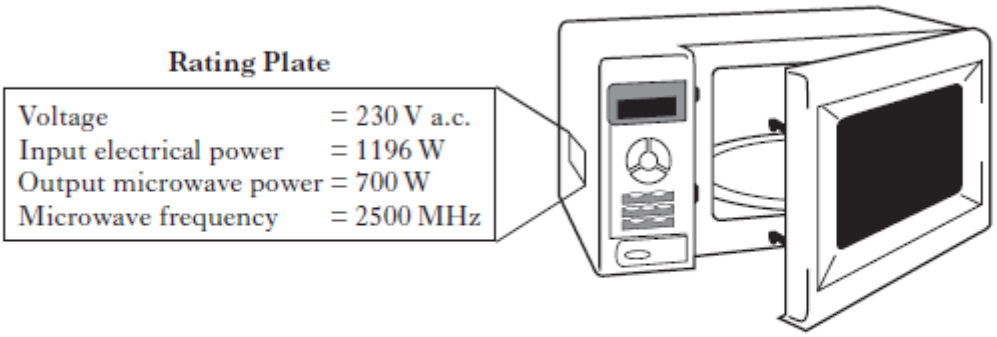
(*c*) Calculate the percentage efficiency of the pulley system. **2**

(6)

NA

Marks

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



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

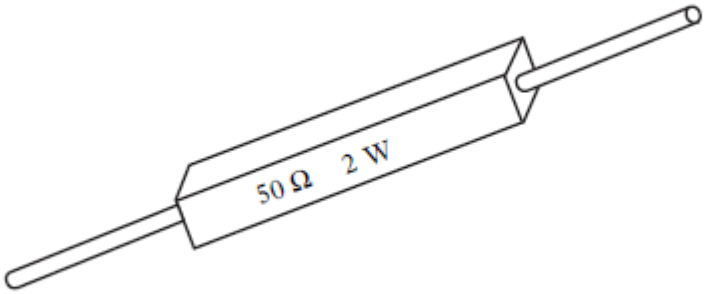
(*b*) (i) Calculate the input current. **2**

(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**

Potential Difference (volts)

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.

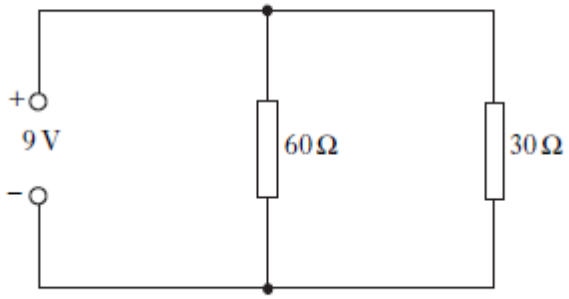


(*a*) A resistor is labelled 50 Ω, 2 W.

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**

(9)

Marks

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

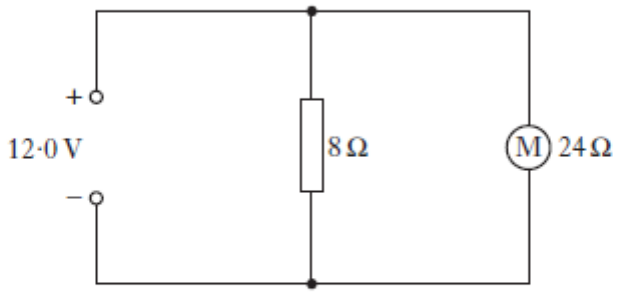
Lamp B: rated 24·0 V, 5·4 Ω

(*a*) Which lamp gives a brighter light when operating at the correct voltage?
Explain your answer. **2**

(*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

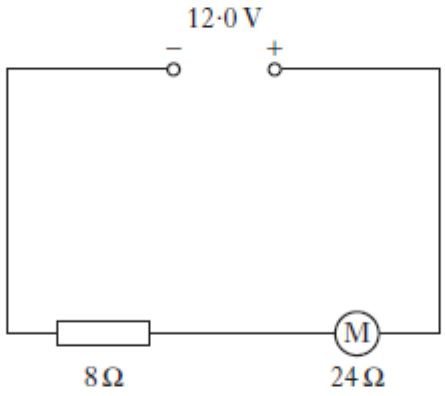
(i) State the voltage across the motor. **1**

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

Marks

26. (continued)

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



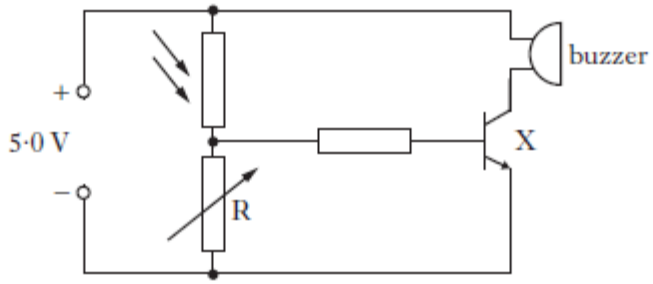
Circuit 2

State how this affects the speed of the motor compared to **Circuit 1**.
Explain your answer. **2**

(10)

Marks

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.

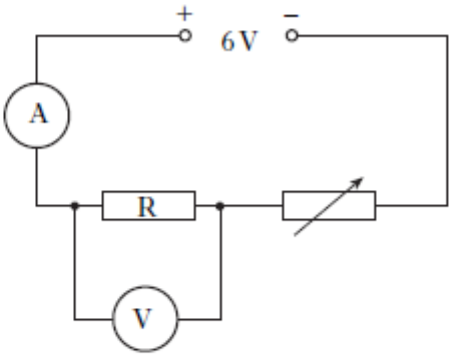
The light level increases to 80 units.

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

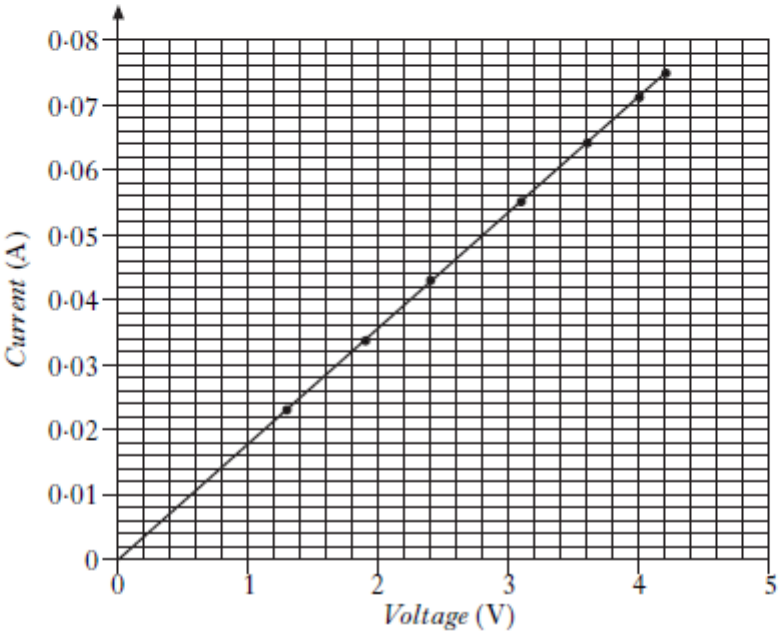
Ohms's Law

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:

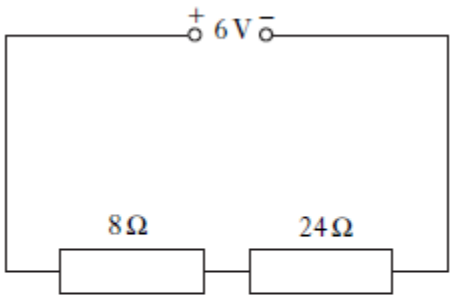
(i) the largest combined resistance; **2**

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

(9)

Marks

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**

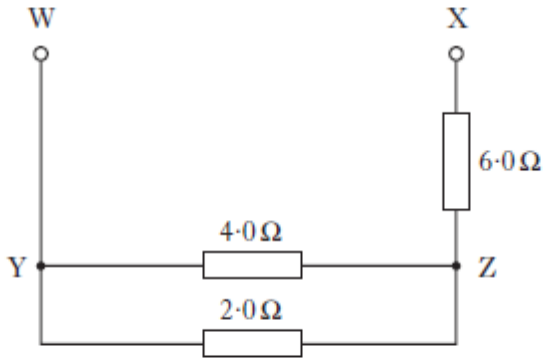
(*c*) The 24 Ω resistor is replaced by one of **greater** resistance. How will this affect the voltage across the 8 Ω resistor?

Explain your answer. **2**

(7)

Marks

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**

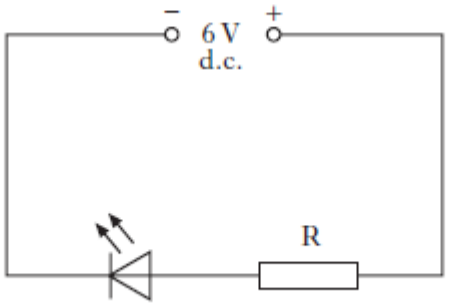
(*c*) Calculate the voltage across the 2·0 Ω resistor when the current in the 4·0 Ω resistor is 0·10 A. **2**

(6)

Marks

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)

Marks

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?

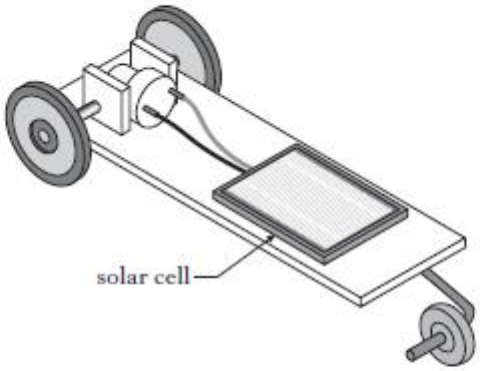
Explain your answer. **2**

(10)

Electrical Power

Marks

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**

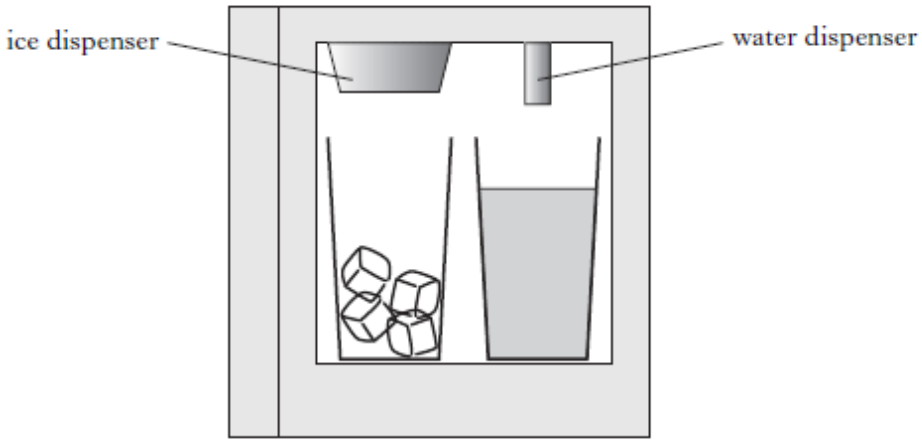
(ii) The buggy requires 4 mW to operate. Calculate the number of solar cells required to supply this power. **2**

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

Specific Heat Capacity

Marks

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**

Marks

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**

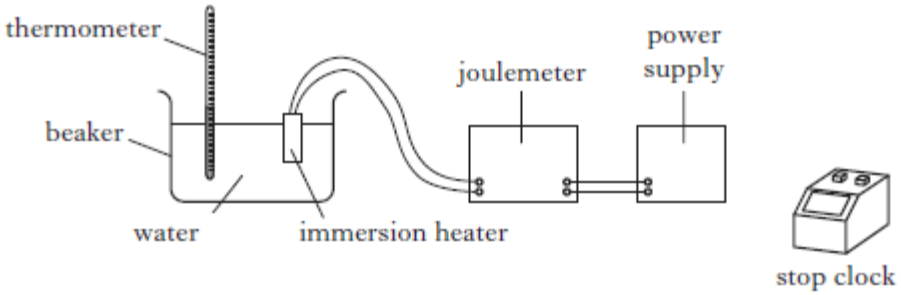
(*c*) Energy from these rocks could be used to heat a base on the surface of Mercury.
How many 60 kg rocks would be needed to supply a 288 kW heating system? **2**

(*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)

Marks

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**

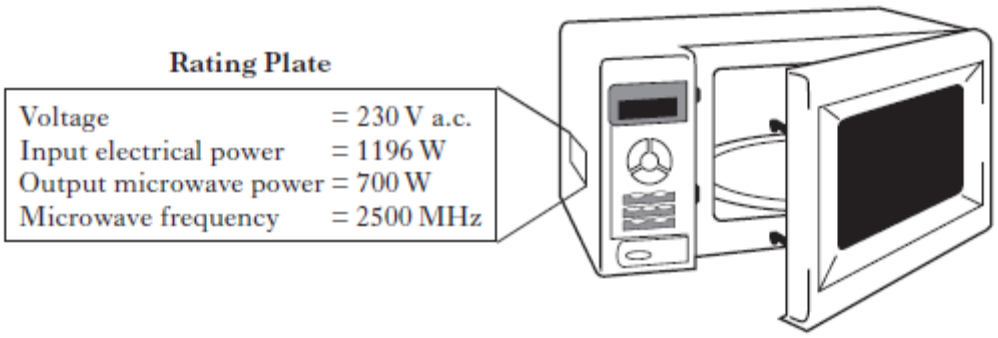
(ii) How could the experiment be improved to reduce this difference? **1**

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

(9)

Marks

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



(*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**

(iii) The milk of mass 0·25 kg absorbs 48 kJ of energy during the heating process. The specific heat capacity of milk is 3900 J/kg °C.

Calculate the temperature rise in the milk. **2**

(*c*) Calculate the wavelength of the microwaves. **2**

(9)