C

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3220/402

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PHYSICS
STANDARD GRADE
Credit Level

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Date of birth

Day		Month		Year	

Scottish candidate number

Number of seat

Reference may be made to the Physics Data Booklet.

1 All questions should be answered.

2 The questions may be answered in any order but all answers must be written clearly and legibly in this book.

3 Write your answer where indicated by the question or in the space provided after the question.

4 If you change your mind about your answer you may score it out and rewrite it in the space provided at the end of the answer book.

5 If you use the additional space at the end of the answer book for answering any questions, you **must** write the correct question number beside each answer.

6 Before leaving the examination room you must give this book to the invigilator. If you do not, you may lose all the marks for this paper.

7 Any necessary data will be found in the **data sheet** on page three.

8 Care should be taken to give an appropriate number of significant figures in the final answers to questions.

Use **blue** or **black ink**. Pencil may be used for graphs and diagrams only.

SQA

©

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DATA SHEET

Speed of light in materials

Material	Speed in m/s
Air	$3 \cdot 0 \times 10^8$
Carbon dioxide	$3 \cdot 0 \times 10^8$
Diamond	$1 \cdot 2 \times 10^8$
Glass	$2 \cdot 0 \times 10^8$
Glycerol	$2 \cdot 1 \times 10^8$
Water	$2 \cdot 3 \times 10^8$

Speed of sound in materials

Material	Speed in m/s
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Gravitational field strengths

	Gravitational field strength on the surface in N/kg
Earth	10
Jupiter	26
Mars	4
Mercury	4
Moon	$1 \cdot 6$
Neptune	12
Saturn	11
Sun	270
Venus	9

Specific heat capacity of materials

Material	Specific heat capacity in J/kg °C
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Glycerol	2400
Ice	2100
Lead	128
Silica	1033
Water	4180

Specific latent heat of fusion of materials

Material	Specific latent heat of fusion in J/kg
Alcohol	$0 \cdot 99 \times 10^5$
Aluminium	$3 \cdot 95 \times 10^5$
Carbon dioxide	$1 \cdot 80 \times 10^5$
Copper	$2 \cdot 05 \times 10^5$
Glycerol	$1 \cdot 81 \times 10^5$
Lead	$0 \cdot 25 \times 10^5$
Water	$3 \cdot 34 \times 10^5$

Melting and boiling points of materials

Material	Melting point in °C	Boiling point in °C
Alcohol	−98	65
Aluminium	660	2470
Copper	1077	2567
Glycerol	18	290
Lead	328	1737
Turpentine	−10	156

Specific latent heat of vaporisation of materials

Material	Specific latent heat of vaporisation in J/kg
Alcohol	$11 \cdot 2 \times 10^5$
Carbon dioxide	$3 \cdot 77 \times 10^5$
Glycerol	$8 \cdot 30 \times 10^5$
Turpentine	$2 \cdot 90 \times 10^5$
Water	$22 \cdot 6 \times 10^5$

SI Prefixes and Multiplication Factors

Prefix	Symbol	Factor	
giga	G	1 000 000 000	$= 10^9$
mega	M	1 000 000	$= 10^6$
kilo	k	1000	$= 10^3$
milli	m	0·001	$= 10^{-3}$
micro	μ	0·000 001	$= 10^{-6}$
nano	n	0·000 000 001	$= 10^{-9}$

Marks

1. A laptop computer uses a radio signal to transfer information to a base station. The base station is connected by optical fibres to a telephone exchange.

optical fibres

laptop

Telephone exchange
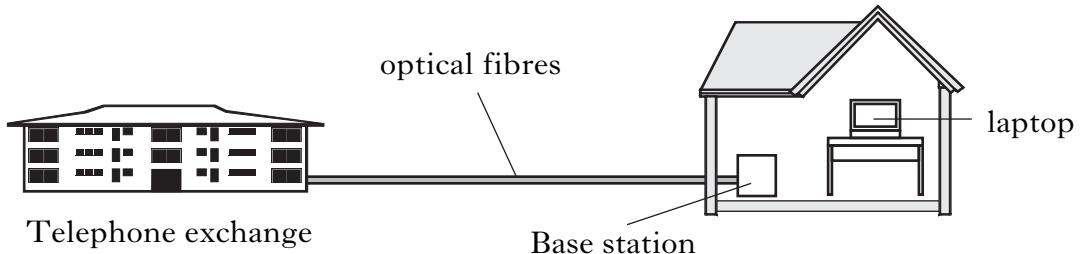
Base station

(*a*) The frequency of the radio signal is 5 GHz.

  (i) State the speed of the radio signal.

  .... **1**

  (ii) Calculate the wavelength of the radio signal.

  Space for working and answer

  2

(*b*) The telephone exchange is 40 km away from the base station.

  Calculate the time taken for the signal to travel along the **glass** optical fibre from the base station to the local telephone exchange.

  Space for working and answer

  3

(*c*) Copper wire can also be used to transfer information between the base station and the telephone exchange.

  State **one** advantage of using optical fibres compared to copper wire.

  .... **1**

Marks

2. A ship is carrying out a survey of the sea bed using ultrasound waves.

When stationary, the ship transmits and receives pulses of ultrasound waves. The transmitted ultrasound waves have a frequency of 30 kHz.

transmitted   received
pulse   pulse
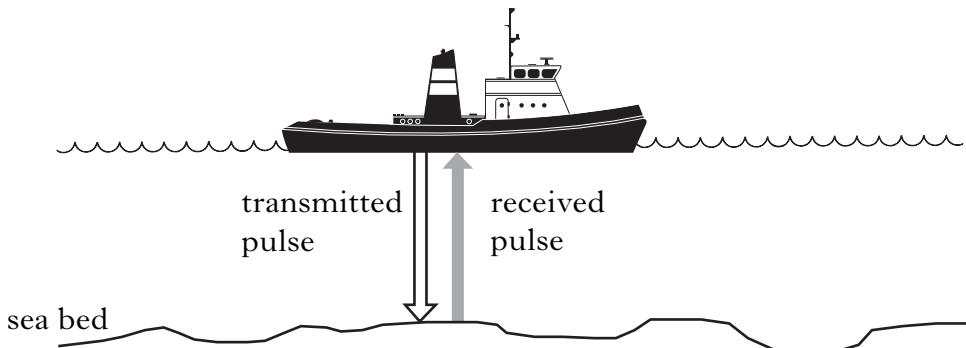
sea bed

(*a*) What is meant by ultrasound?

....   **1**

(*b*) What is the speed of ultrasound waves in water?

....   **1**

(*c*) One pulse of ultrasound is received back at the ship 0·36 s after being transmitted.

Calculate the depth of the sea bed.

Space for working and answer

  3

[Turn over

Marks

3. A rock concert is being held at Hampden Stadium. The concert is being filmed and is displayed on a large screen above the stage. This allows the band to be seen clearly by people at the back of the stadium.
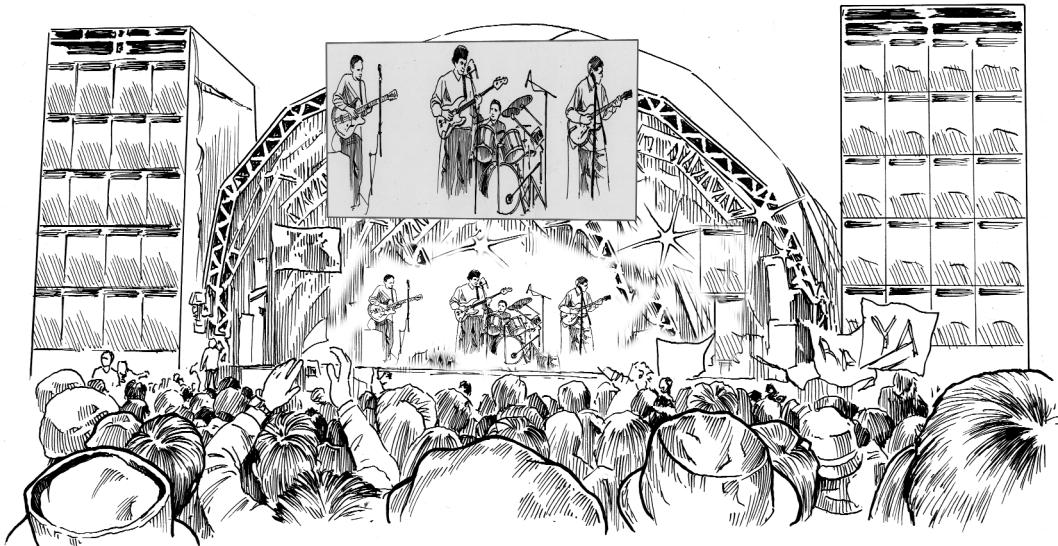
(*a*) The people at the back of the stadium, watching the screen, notice that there is a time delay between seeing the drummer hitting the drums and hearing the sound.

Explain why there is a time delay.

....

....   **1**

(*b*) The concert is also being broadcast live on radio and television.

The audio signal is combined with a radio carrier wave to produce a modulated radio signal.

The audio signal and the modulated radio signal are shown below.

Draw the radio carrier wave in the space provided.
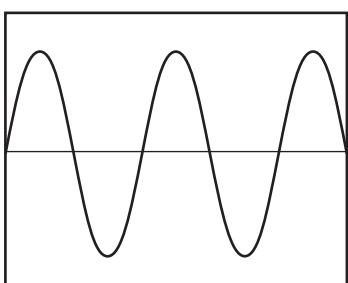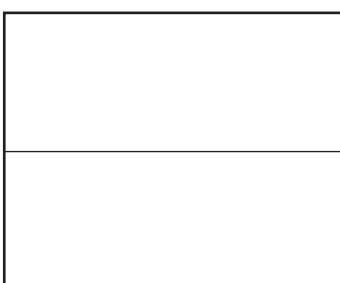
audio signal   radio carrier wave   modulated radio signal

2

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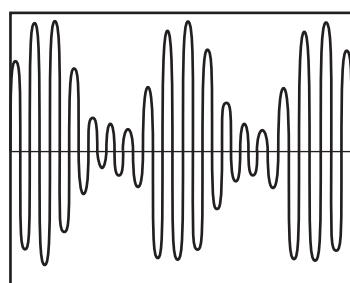
Marks

3. (continued)

(*c*) An electric guitar used in the concert is connected to an amplifier.
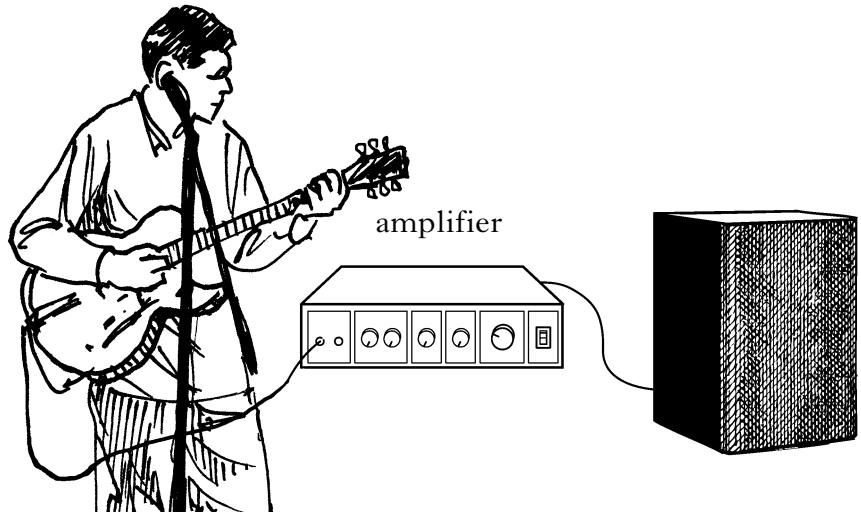
amplifier

The input power of the signal from the guitar to the amplifier is 30 mW.
The output of the amplifier is connected to a loudspeaker.
The amplifier has a power gain of 25 000.

Calculate the output power delivered to the loudspeaker.

Space for working and answer

2

[Turn over

4. A car fan uses a battery powered electric motor. The diagram below shows the apparatus used to investigate the effect of current on the speed of the electric motor.
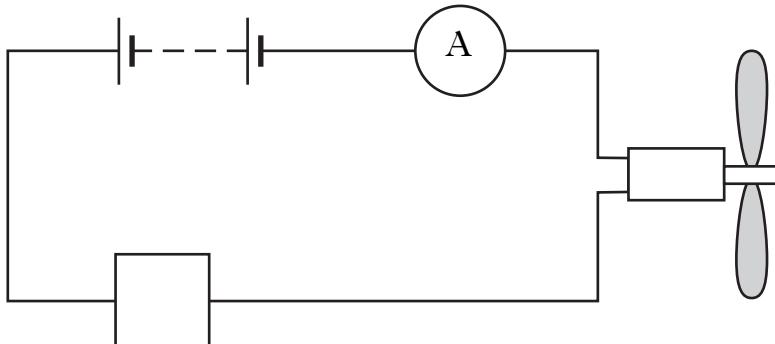
variable speed control

(*a*) The graph shows the relationship between speed and current during the investigation.

speed in m/s
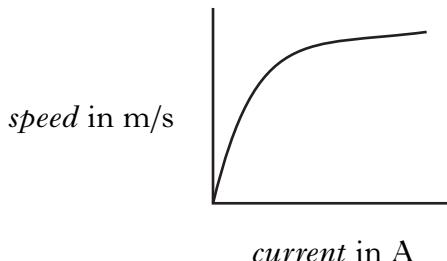
current in A

(i) The current is changed using the variable speed control.

What happens to the current when the resistance of the variable speed controller is reduced?

.... **1**

(ii) The settings of the variable speed control use different combinations of **identical** resistors, as shown.

from battery
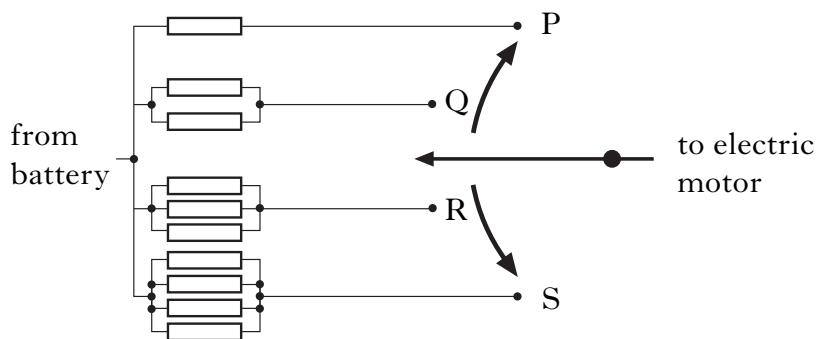
to electric motor

(A) To which position should the variable speed control be set to achieve maximum speed?

.... **1**

(B) Justify your answer.

.... **1**

4. (continued)

(*b*) The electric motor is shown below.

carbon brushes
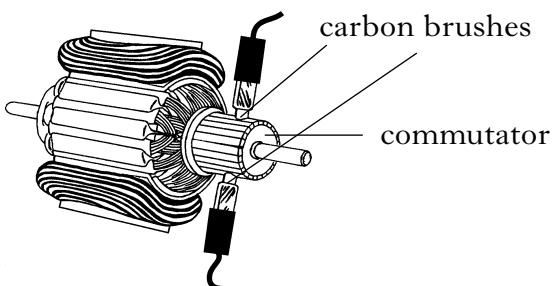
commutator

(i) Explain the purpose of the commutator.

....

.... **1**

(ii) Why are the brushes made of carbon rather than metal wire?

.... **1**

(*c*) When a wire carrying a current is placed in a magnetic field, a force is produced on the wire. The diagram shows the direction of the force for a particular situation.

force   wire

N   S

current direction
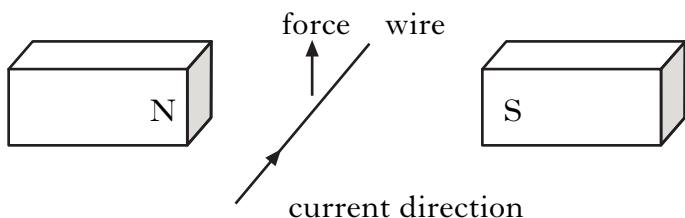
(i) A simplified diagram of an electric motor is shown below. Indicate on the diagram the direction of the force on the wire at point X and point Y. **1**

N   X   Y   S
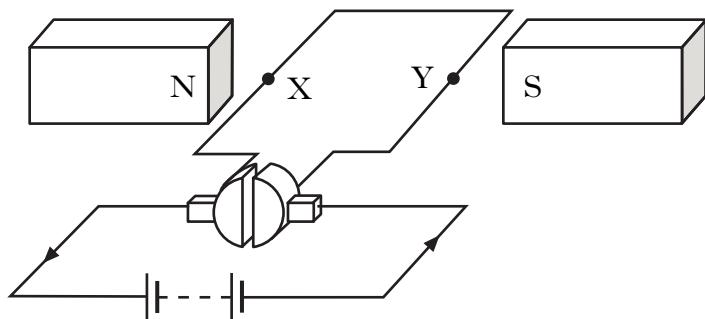
(ii) State **one** way in which the direction of rotation of the motor could be reversed.

.... **1**

Marks

5. A householder plugs a home entertainment centre, a hi-fi, a games console and an electric fire into a multiway adaptor connected to the mains.

home entertainment centre

multiway adaptor

games console

hi-fi
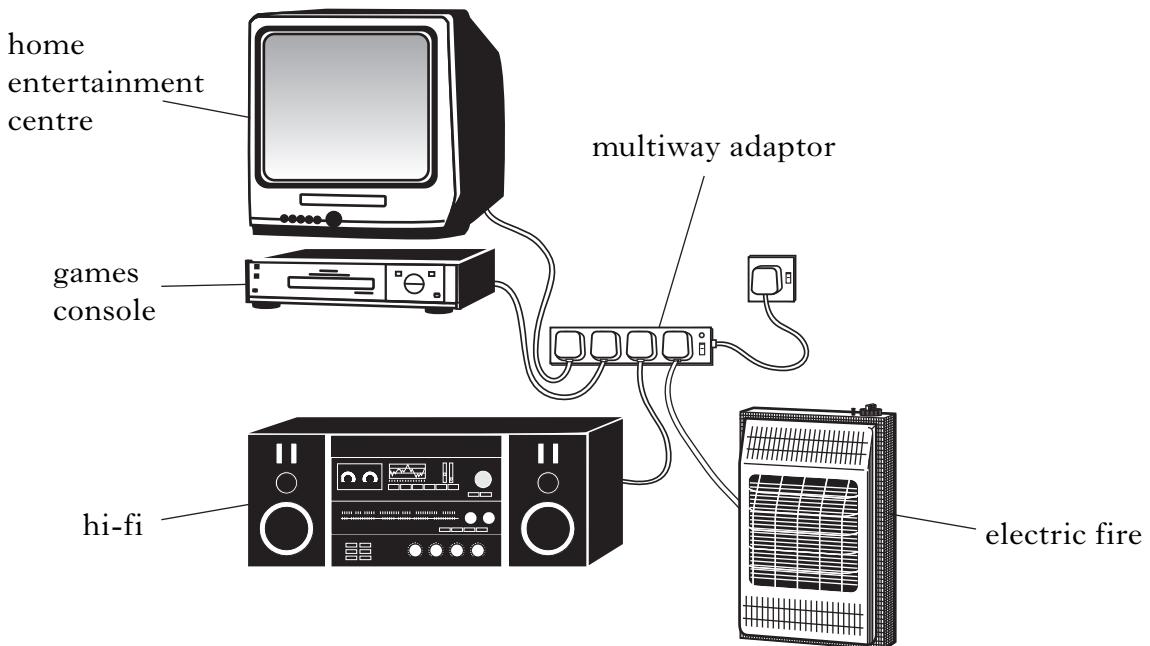
electric fire

The wiring in the electric fire is found to be faulty. The circuit is shown below.

brown

heating elements

green and yellow

blue

S
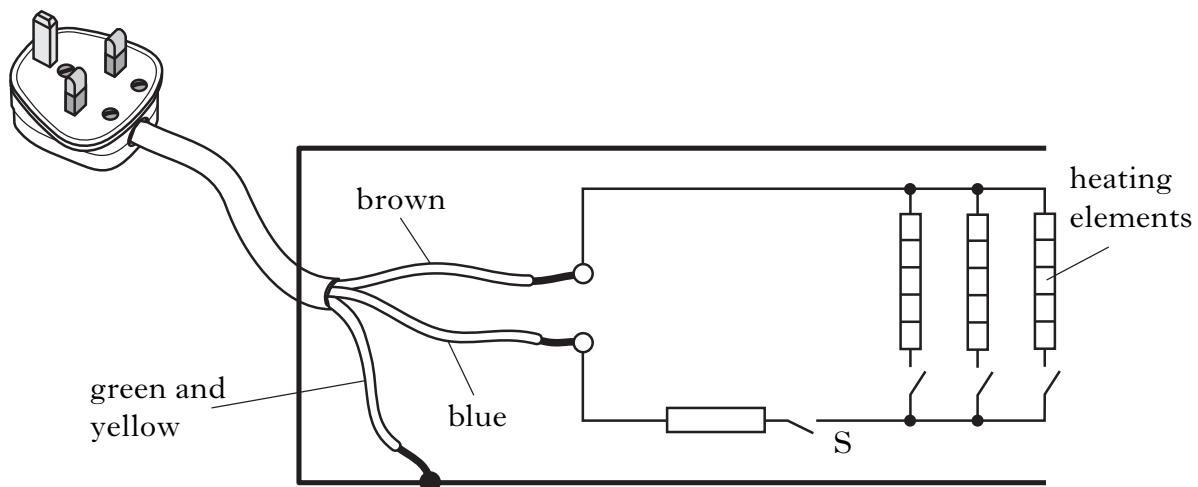
(*a*) What is the fault in the circuit?

....

.... **1**

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Marks

5. (continued)

(*b*) The householder goes on holiday for 14 days.

The electric fire is unplugged.

All the other appliances are left on standby.

On standby, these appliances operate at 9·0 % of their power rating listed in the table.

Appliance	*Power rating* (W)
home entertainment centre	350
hi-fi	150
games console	300
electric fire	2080

(i) Calculate the total power consumption, in watts, of all the appliances left **on standby**.

Space for working and answer

2

(ii) Calculate the number of kilowatt-hours used by these appliances during the 14 days on standby.

Space for working and answer

2

[Turn over

Marks

6. In a physics laboratory, a student wants to find the focal length of a convex lens. The student is given a sheet of white paper, a metre stick and a lens.

paper

Convex lens

metre stick
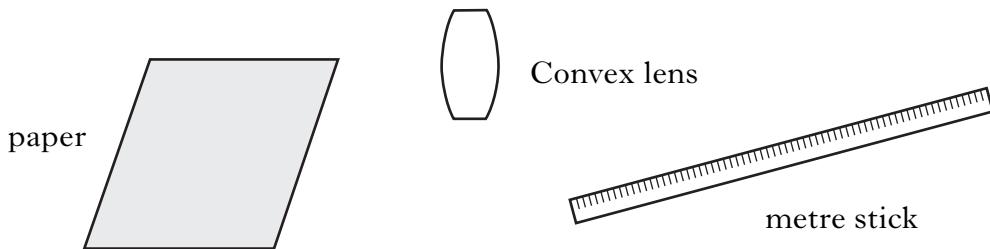
(*a*) Explain how the student could measure the focal length of the lens using this equipment.

....

.... **2**

(*b*) Refraction of light occurs in lenses.

What is meant by the term refraction?

....

.... **2**

(*c*) The following diagram shows a ray of light entering a glass block.

(i) Complete the diagram to show the path of the ray of light through the block and after it emerges from the block.

air   glass   air

normal

ray of light
entering block

glass block
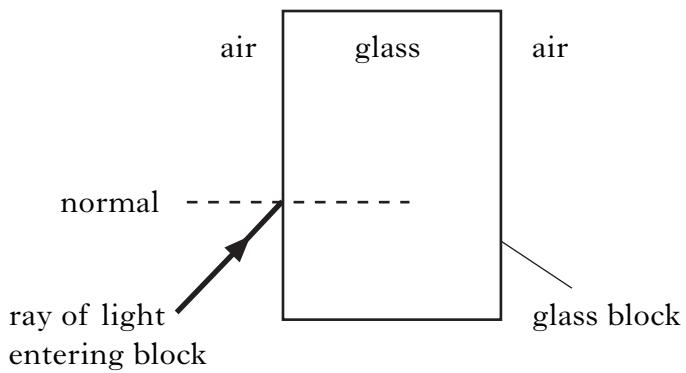
2

(ii) On your diagram indicate an angle of refraction, **r**. **1**

Marks

7. Students observe an experiment with radioactive sources. The radiation is measured using a detector and counter. The background count rate is measured.

stop clock   detector   counter
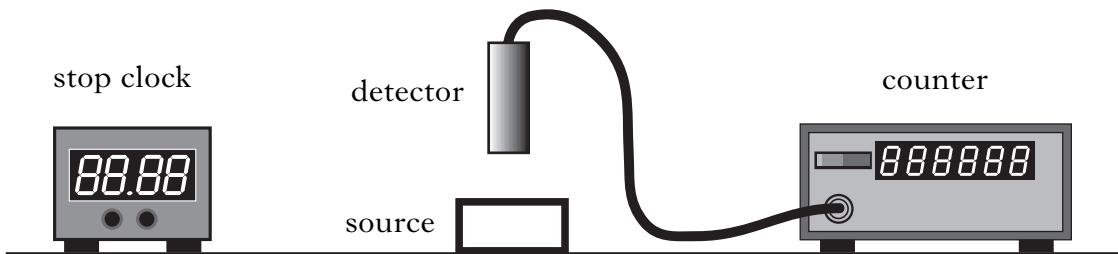
source

Different absorbing materials are then placed, in turn, between source and detector and readings for each material are recorded. This is repeated for each source. The results are shown in the table.

	Corrected Count Rate (Counts per minute)			
Source	*No absorbing material*	*Paper*	*2 cm of Aluminium*	*2 cm of Lead*
A	480	480	480	200
B	720	300	300	180
C	600	580	0	0

One source emits beta radiation only, one emits gamma only and one emits both alpha and gamma radiation.

(*a*) Complete the following table to identify the source.

Type of radiation	*Source*
beta only	
both alpha and gamma	

1

(*b*) One source has a half-life of 30 minutes.
The source has an initial activity of 18 000 Bq.
Calculate its activity after 2 hours.

Space for working and answer

2

Marks

8. A digital camera is used to take pictures. When switched on, the flash on a digital camera requires some time before it is ready to operate. When ready, a green LED is illuminated.

LED

digital
camera
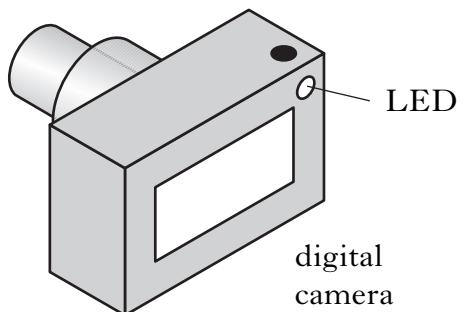
The part of the circuit used to control the LED is shown below. The voltage at point X is initially 0 V.

S

R

6 V

X

capacitor
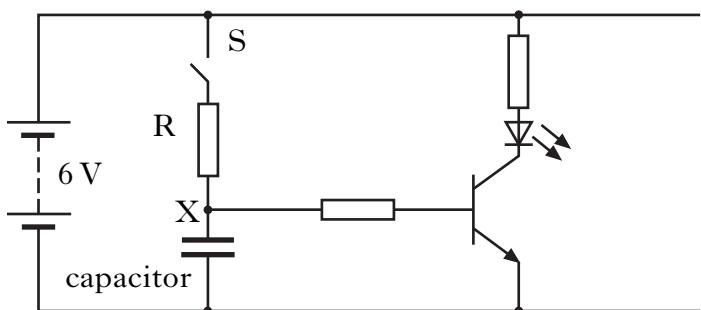
(*a*) Describe what happens to the voltage at point X when switch S is closed.

.... **1**

(*b*) The camera manufacturer wants to change the time taken for the flash to be ready to operate.

State **two** changes which could be made to the above circuit so that the time for the green LED to come on is **reduced**.

....

.... **2**

Marks

8. (continued)

(*c*) The camera flash is designed to operate under dim lighting conditions. Another part of the circuit for the camera flash is shown below. The flash only operates when a minimum voltage of 0·7 V occurs across the LDR.
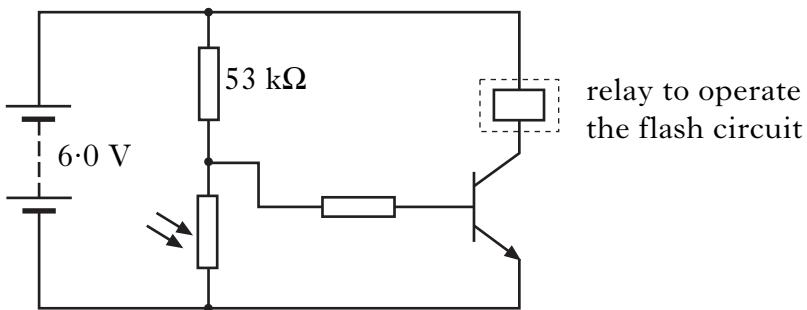
(i) Calculate the voltage across the 53 kΩ resistor when the voltage across the LDR is 0·7 V.

Space for working and answer

1

(ii) Calculate the **minimum** resistance of the LDR that allows the flash to operate in dim conditions.

Space for working and answer

2

[Turn over

Marks

9. A remote gas sensing system detects and identifies whether hydrogen, helium and oxygen gases are present in a sample.

Sensors, consisting of light detectors with filters in front of them, are linked to a processing system that can provide a recognisable output to identify each gas.

The filters allow a limited band of wavelengths to pass through them.

The line spectrum for each gas and the position of filters A, B, C and D are shown below.

Hydrogen

Helium

Oxygen

Filters

A   B   C   D
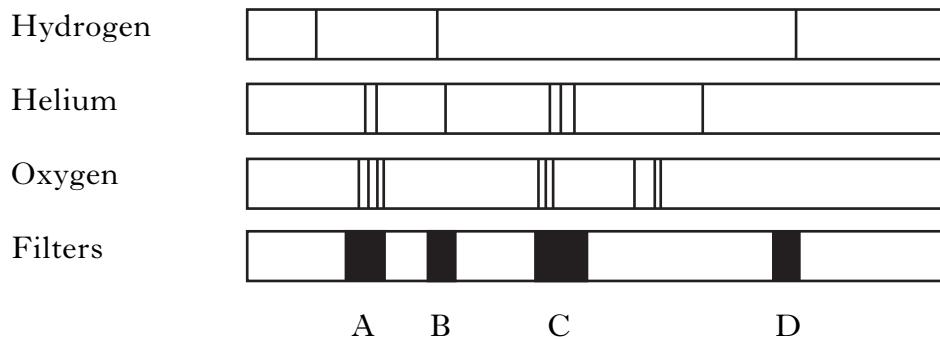
If a spectral line is at the same position as a filter band then that sensor will produce a logic level one.

(*a*) Suggest a suitable input device for the sensor.

.... **1**

(*b*) Complete the truth table for the sensor outputs when each gas is detected. Hydrogen has already been completed.

Gas	Sensor			
	A	B	C	D
Hydrogen	**0**	**1**	**0**	**1**
Helium				
Oxygen				

2

Marks

9. (continued)

(*c*) The logic circuit used to identify one of these gases is shown.
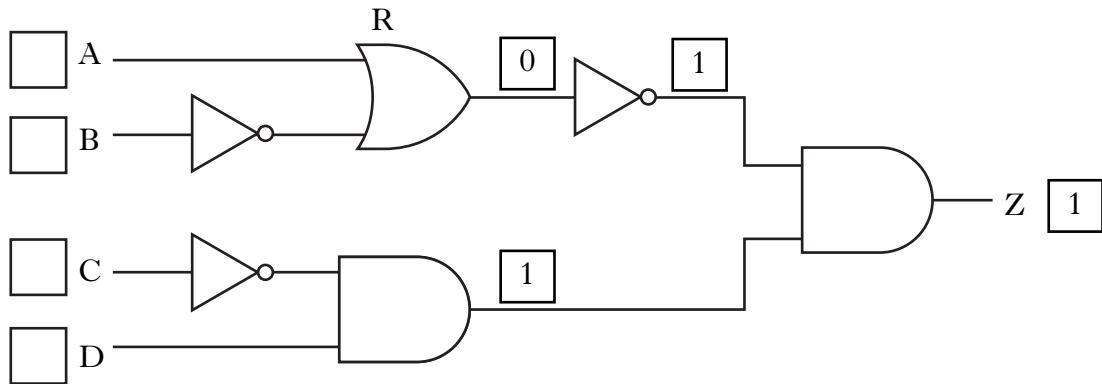
(i) Name logic gate R.

.... **1**

(ii) When this gas is present, a logic 1 is output at Z.

(A) Complete the boxes A, B, C and D in the logic circuit.

(B) Name which gas is detected with this circuit.

.... **2**

**[Turn over**

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10. A parachutist jumps out of an aircraft. Sometime later, the parachute is opened.

The graph shows the motion of the parachutist from leaving the aircraft until landing.

speed in
m/s

A   B   C   D   E

time in s
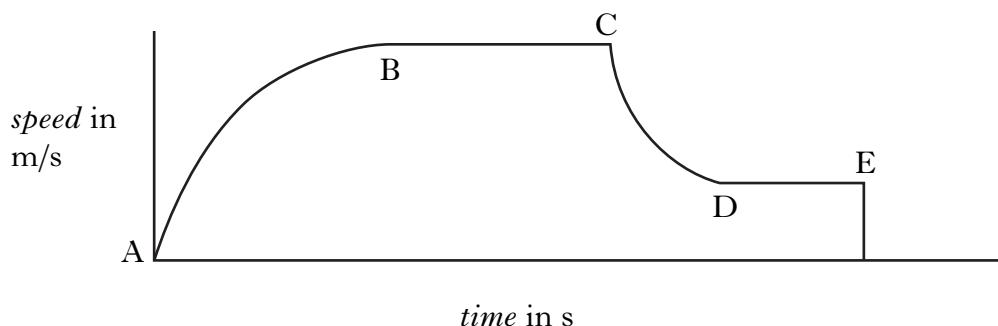
(*a*) Which parts of the graph show when the forces acting on the parachutist are balanced?

.... **1**

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Marks

10. (continued)

(*b*) The parachutist lands badly and is airlifted to hospital by helicopter.
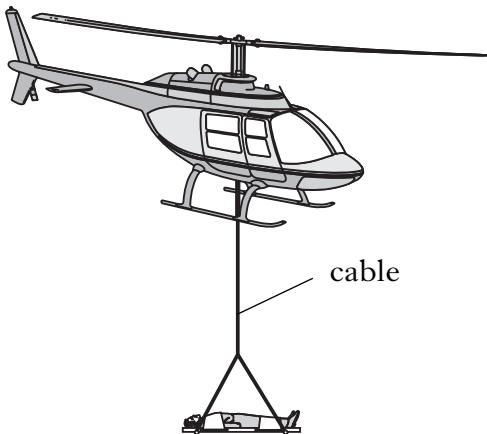
cable

The stretcher and parachutist have a total mass of 90·0 kg.

(i) Calculate the weight of the stretcher and parachutist.

Space for working and answer

2

(ii) The helicopter cable provides an upward force of 958·5 N to lift the stretcher and parachutist.

Calculate the acceleration of the stretcher and parachutist.

Space for working and answer

3

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Marks

11. Two students set up a linear air track experiment. A linear air track consists of a hollow tube with small holes. Air is blown through the small holes. A vehicle moves on the cushion of air.

The vehicle starts from rest at **X** and moves along the air track so that the card passes through the light gate at point **Y**.
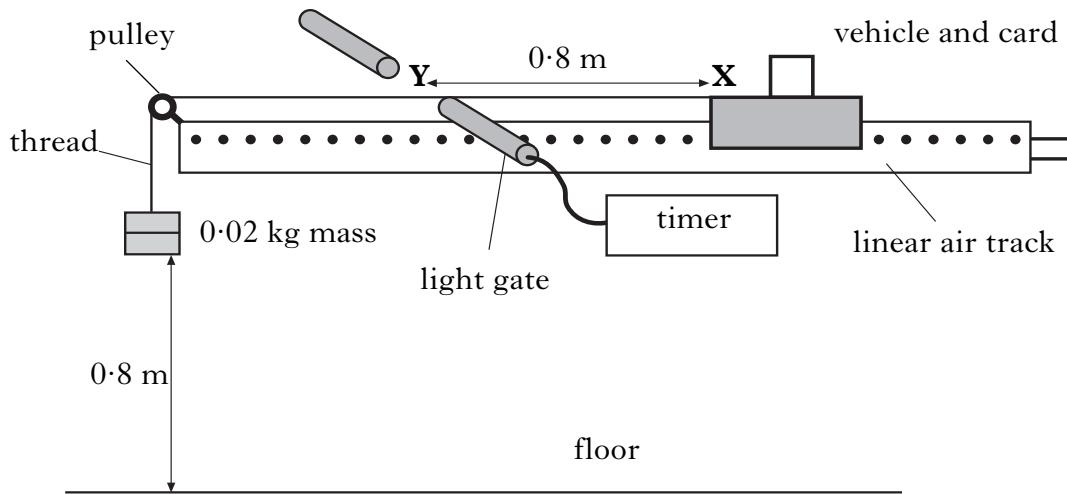
The results for one experiment are recorded in the table below.

Card Length (cm)	Speed at **X** (m/s)	Timer Reading at **Y** (s)	Speed at **Y** (m/s)	Time to travel from **X** to **Y** (s)	Acceleration between **X** and **Y** (m/s^2)
3	0	0·05	0·6	1·5	

(*a*) Use the information given in the table to calculate the acceleration of the vehicle between **X** and **Y**.

Space for working and answer

2

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Marks

11. (continued)

(*b*) When repeating the experiment, the 0·02 kg mass detaches from the thread before the vehicle is released. The mass falls 0·80 m to the floor.

(i) Calculate the gravitational potential energy stored in the mass before it fell.

Space for working and answer

2

(ii) Assuming the mass falls from rest, calculate the final speed of the mass just before it hits the floor.

Space for working and answer

3

[Turn over

12. A hovercraft service was trialled on the Firth of Forth from Kirkcaldy to Leith.
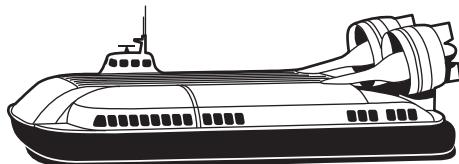
The hovercraft and passengers have a total weight of 220 000 N.

(*a*) State the value of the upward force exerted on the hovercraft when it hovers at a constant height.

.... **1**

(*b*) The graph shows how the speed of the hovercraft varies with time for one journey from Kirkcaldy to Leith.
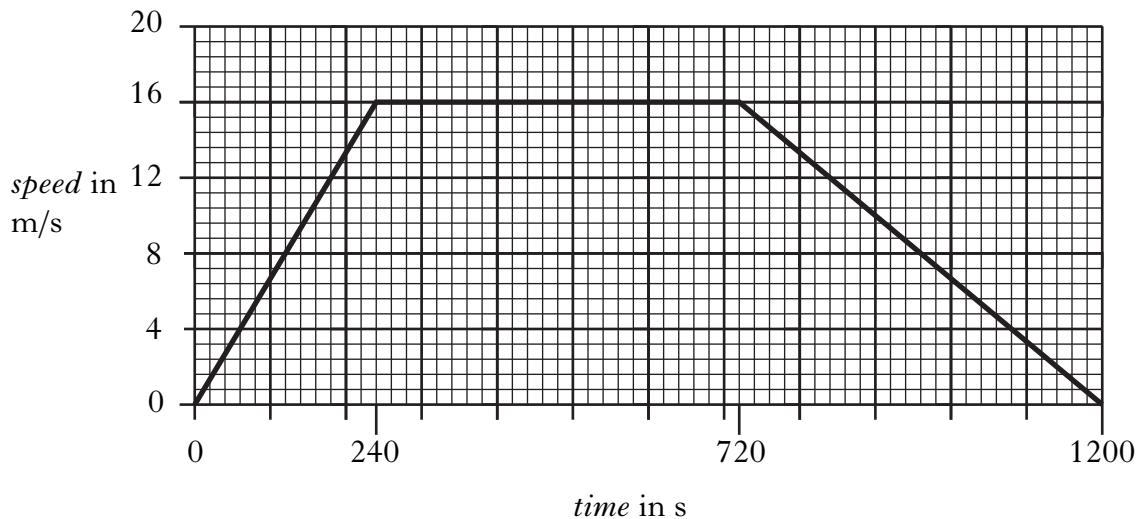
(i) Calculate the total distance travelled during the journey.

Space for working and answer

2

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K&U   PS

Marks

12. (***b***) **(continued)**

      (ii) Calculate the average speed for the whole journey.

> *Space for working and answer*

2

[Turn over

Marks

13. The National Grid transfers electrical energy across the country from power stations using a 132 kV network. Electrical power is generated at 20 kV and 5 kA from the power station generator, before being increased to 132 kV using a transformer.

(*a*) What is the reason for increasing the voltage of the electrical power?

....   **1**
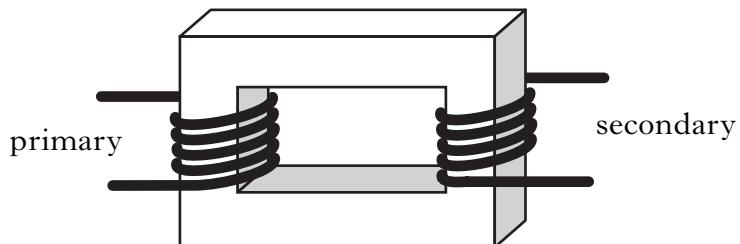
primary   secondary

(*b*) There are 2000 turns in the primary circuit of the transformer. Assuming the transformer is 100 % efficient:

(i) calculate the number of turns in the secondary coil;

Space for working and answer

2

(ii) calculate the current in the secondary coil of the transformer.

Space for working and answer

2

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13. (continued)

(*c*) The secondary coil of the transformer is connected to the high voltage National Grid network.   High voltage cable has a resistance of 0·31 Ω/km. One cable has a length of 220 km.

Calculate the power loss in this cable.

> *Space for working and answer*

3

[Turn over

Marks

14. A solar furnace consists of an array of mirrors which reflect heat radiation on to a central curved reflector.

A heating container is placed at the focus of the central curved reflector. Metals placed in the container are heated until they melt.

The diagram below shows the heat rays after reflection by the mirrors on the hillside.

(*a*) Complete the diagram to show the effect of the central curved reflector on the heat rays.

2

heating container

heat

rays

central curved reflector
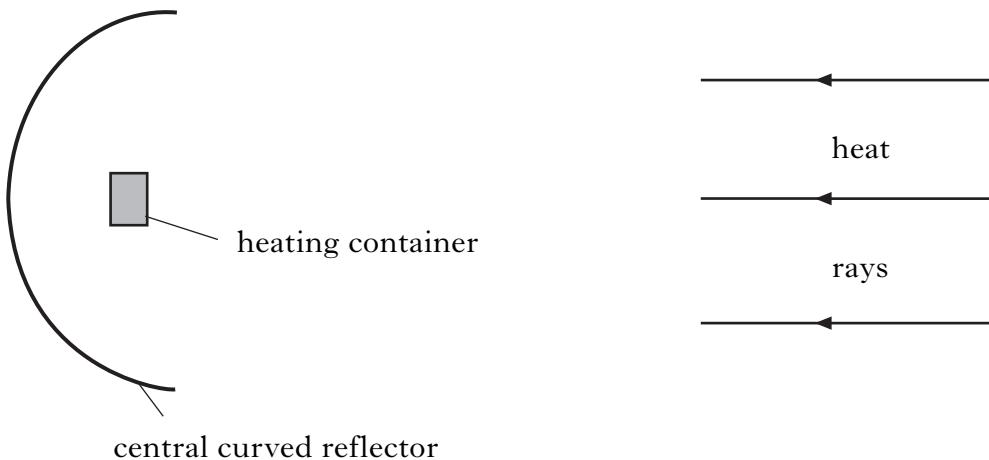
Marks

14. **(continued)**

(*b*) 8000 kg of pre-heated aluminium pellets at a temperature of 160 °C are placed in the container. Aluminium has a specific heat capacity of 902 J/kg °C and a melting point of 660 °C.

How much heat energy is required to heat the aluminium to its melting point?

Space for working and answer

2

(*c*) (i) How much extra energy is required to melt the aluminium pellets?

Space for working and answer

3

(ii) The power of the furnace is 800 kW. How long will it take for this extra energy to be supplied?

Space for working and answer

2

(iii) Explain why it takes longer, in practice, to melt the aluminium.

....

.... **1**

[Turn over

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15. A space probe is designed to record data on its way to landing on Ganymede, a moon of Jupiter. The launch vehicle is made up of the probe of mass 8000 kg and the constant thrust rocket unit which has a mass of 117 000 kg.

Probe 8000 kg

constant thrust rocket unit
117 000 kg
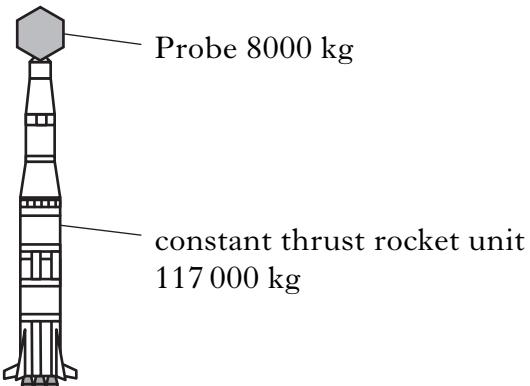
On launch, the resultant force acting upwards on the launch vehicle is 1 400 000 N.

(*a*) Calculate the initial acceleration of the launch vehicle.

Space for working and answer

2

(*b*) As the launch vehicle continues to ascend, its acceleration increases. This is partly due to the decrease in gravitational field strength as it gets further from Earth.

Give another reason why the acceleration increases.

.... 1

15. (continued)

(*c*) The space probe eventually goes into orbit around Ganymede.

Ganymede

probe

Not to scale
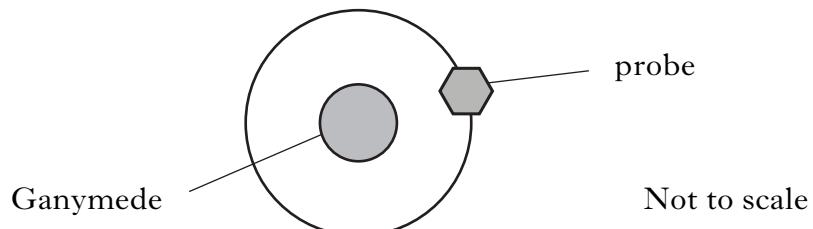
Explain why the probe follows a circular path while in orbit.

....

....

.... **2**

(*d*) The probe has gas thrusters that fire to slow it down in order to land on Ganymede. In terms of Newton's laws, explain how these thrusters achieve this task.

....

....

.... **2**

[Turn over

Marks

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K&U   PS

16. (*a*) Astronomers use refracting telescopes to observe planets. A refracting telescope has an eyepiece lens and an objective lens.

(i) An eyepiece lens can be used on its own as a magnifying glass. Complete the ray diagram to show how the eyepiece lens forms a magnified image.

2

image

object

focus   focus
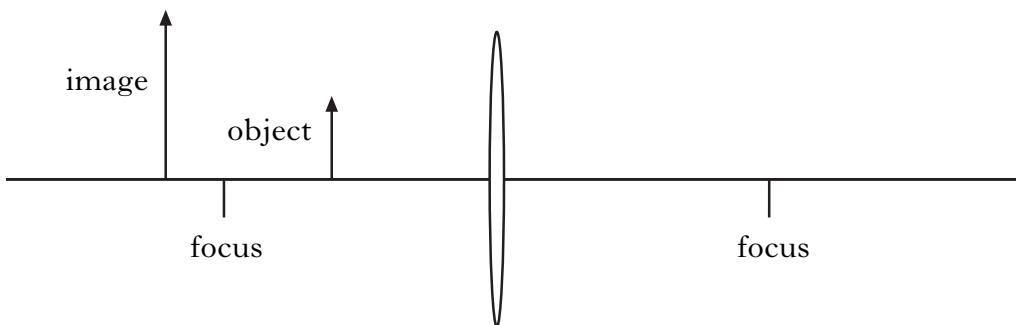
(ii) How does the diameter of the objective lens affect the image seen through the telescope?

.... **1**

Marks

16. (continued)

(*b*) Radio waves emitted by galaxies are detected and used to provide images of the galaxies.

   (i)   How does the wavelength of radio waves compare with the wavelength of light?

1

....

   (ii) Name a detector for radio waves.

1

....

   (iii) Why are different kinds of telescope used to detect signals from space?

....

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1

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[*END OF QUESTION PAPER*]

ADDITIONAL SPACE FOR ANSWERS

Make sure you write the correct question number beside each answer.