FOR OFFICIAL USE

C

K & U PS

Total Marks

3220/402

NATIONAL QUALIFICATIONS 2005

TUESDAY, 24 MAY
10.50 AM – 12.35 PM

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

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 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.

6 Any necessary data will be found in the **data sheet** on page two.

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

SAB 3220/402 6/3/3/23970

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	1·6
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
Diamond	530
Glass	500
Glycerol	2400
Ice	2100
Lead	128
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	$0{\cdot}001 = 10^{-3}$
micro	μ	$0{\cdot}000\,001 = 10^{-6}$
nano	n	$0{\cdot}000\,000\,001 = 10^{-9}$

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

1. A car driver listens to a radio station broadcasting on 1500 kHz.

(*a*) Calculate the wavelength of the radio broadcast.

Space for working and answer

2

(*b*) The table shows the frequency range of the different wavebands on the radio receiver.

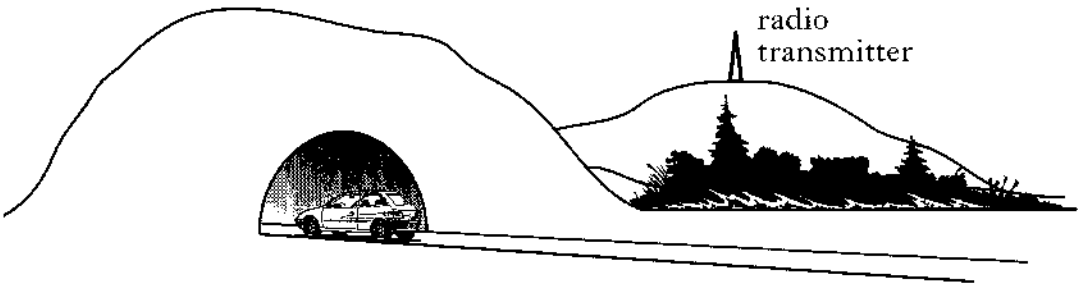
Waveband	*Frequency range*
long wave	30 kHz – 300 kHz
medium wave	300 kHz – 3 MHz
short wave	3 MHz – 30 MHz
F.M.	30 MHz – 300 MHz

From the table, write down the waveband of the radio station that the driver is listening to.

.....

1

(*c*) A passenger in the car listens to a personal CD player.
The car enters a tunnel.



As the car enters the tunnel, the sound from the radio fades, but the sound from the CD player can still be heard.

(i) Explain why the sound from the radio fades.

.....

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1

(ii) Explain why the sound from the CD player can still be heard.

.....

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1

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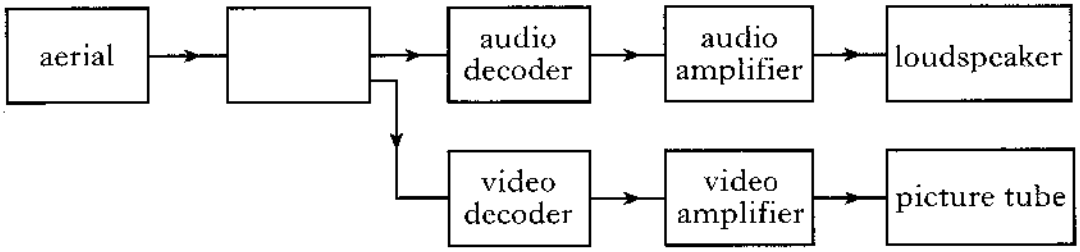
Marks | K&U | PS

2. A television receiver is used to pick up a signal from a television transmitter.

(*a*) The block diagram represents a television receiver.



(i) On the diagram, label the part of the receiver that has been left blank. **1**

(ii) State the purpose of the aerial.

.....

..... **1**

(iii) One other necessary part of the television receiver is not shown on the block diagram.

Name this part.

..... **1**

(iv) Which part of the television receiver transforms electrical energy to light energy?

..... **1**

(*b*) In the transmitter, a video signal is combined with a carrier wave to produce a signal for transmission.

(i) Circle the correct phrase to complete this sentence.

The carrier wave has a frequency that is $\left\{\begin{matrix}\text{higher than}\\ \text{the same as}\\ \text{lower than}\end{matrix}\right\}$ the frequency of the video signal. **1**

(ii) Why is the carrier wave needed for transmission?

.....

..... **1**

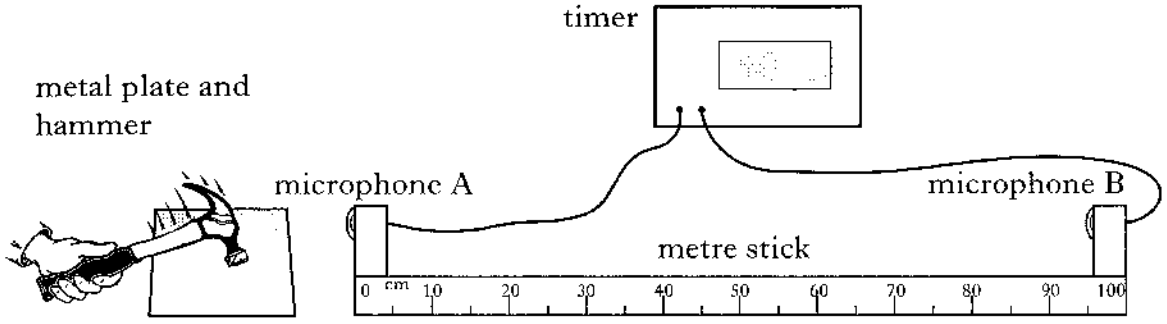
(iii) Name the process of combining the waves for transmission.

..... **1**

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

3. A student sets up the apparatus **exactly** as shown to measure the speed of sound in air.



Striking the metal plate with the hammer produces a sound. Timing starts when the sound reaches microphone A, and stops when the same sound reaches microphone B.

(*a*) The student carries out the experiment three times and records the results shown in the table.

trial	*distance between microphones* (m)	*time recorded on timer* (s)
1	1·00	0·00287
2	1·00	0·00282
3	1·00	0·00286

Use **all** of the student's results to calculate the value of the speed of sound.

Space for working and answer

3

(*b*) Suggest a reason why the student's results do **not** give the value of 340 m/s for the speed of sound in air, as quoted in the data sheet.

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1

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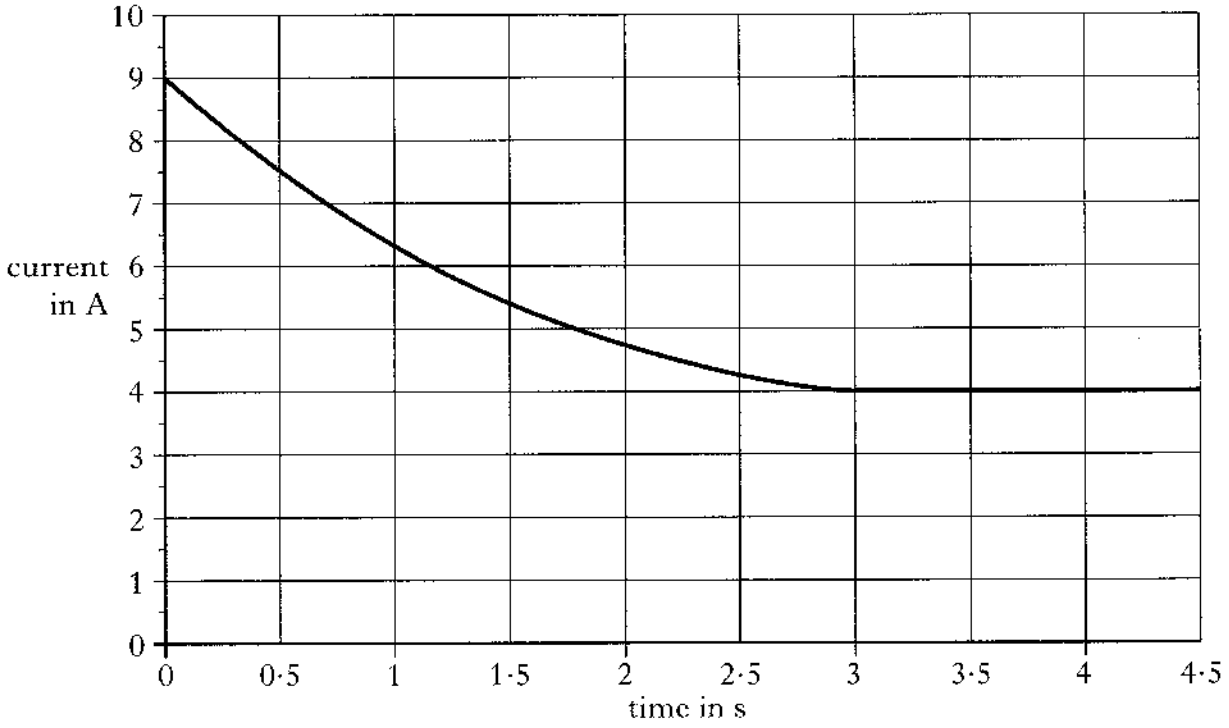
Marks | K&U | PS

4. A mains vacuum cleaner contains a motor that takes 3·0 s to reach full speed after being switched on. The graph shows how the current in the motor varies from the time the motor is switched on.



(*a*) (i) State the current when the motor has reached full speed.

..... **1**

(ii) Calculate the power of the motor when it has reached full speed.

Space for working and answer

3

(*b*) The vacuum cleaner is connected to the mains supply by a flex fitted with a fused plug.

(i) All the fuses shown are available.

3 ampere	5 ampere
10 ampere	13 ampere

Which one of these fuses is **most** suitable for fitting in the plug?

..... **1**

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4. (*b*) (continued)

(ii) State the purpose of the fuse fitted in the plug.

.....

..... **1**

(iii) Explain why the fuse must be connected in the live wire.

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..... **1**

[Turn over

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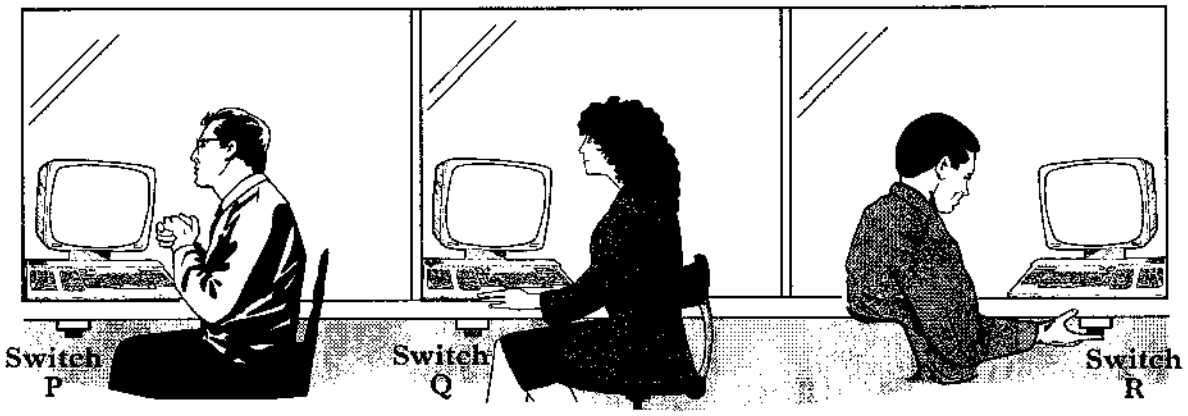
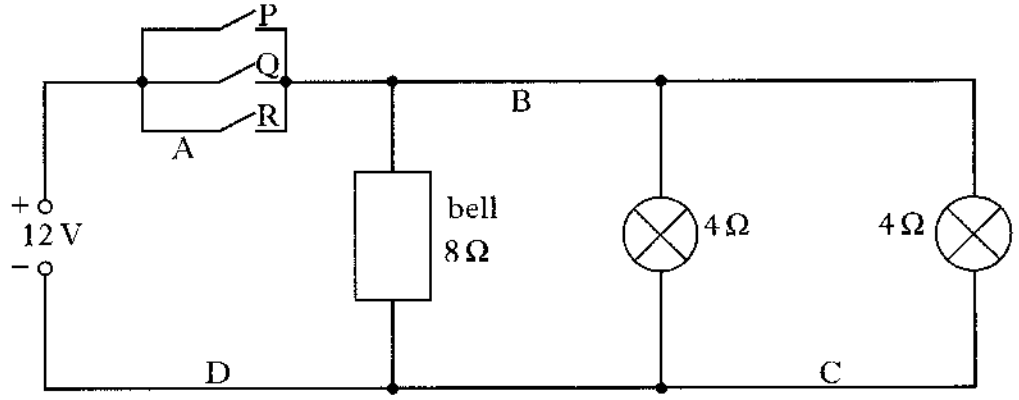
Marks | K&U | PS

5. A post office contains an emergency alarm circuit. Each of three cashiers has an alarm switch fitted as shown. Lamps come on and a bell sounds if an alarm switch is closed.



The circuit diagram for the alarm is shown.



(*a*) The alarm circuit is to be controlled by a master switch.

Which position, A, B, C or D, is most suitable for the master switch?

1

(*b*) Each lamp has a resistance of 4 Ω and the bell has a resistance of 8 Ω. The circuit uses a 12 V supply.

(i) Calculate the total resistance of the alarm circuit.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

5. (*b*) (continued)

(ii) Calculate the current from the supply when the alarm is operating.

Space for working and answer

2

(*c*) Brighter lamps are fitted in the alarm circuit.

Explain how this change affects the resistance of the circuit.

.....

.....

..... **2**

[Turn over

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	Marks	K&U	PS

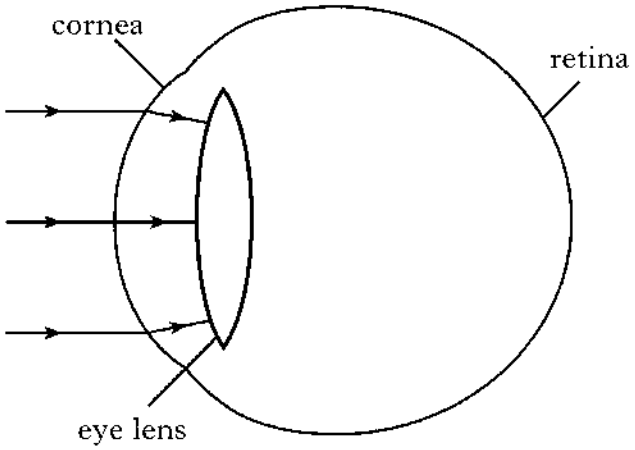
6. In the eye, refraction of light occurs at the cornea and at the eye lens.

(*a*) What is meant by refraction of light?

.....

..... **1**

(*b*) The diagram below shows light rays entering the eye of a short-sighted person.



(i) Complete the diagram above to show how the light rays reach the retina of this short-sighted eye. **1**

(ii) A concave lens of focal length 400 mm is needed to correct the vision in this eye.

Calculate the power of this lens.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

6. (continued)

(*c*) Short-sight can be corrected using a laser to reshape the cornea.

(i) For this treatment a pulsed laser is used. Each pulse lasts for a time of 0·2 ms and transfers 5 mJ of energy.

Calculate the power rating of the laser.

Space for working and answer

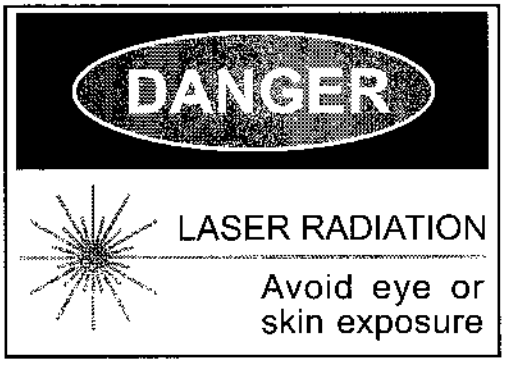
2

(ii) What effect does laser surgery have on the focal length of the cornea?

.....

1

(iii) When a laser is in use, a warning sign similar to the one shown must be displayed.



Why must a warning sign be displayed?

.....

.....

1

[Turn over

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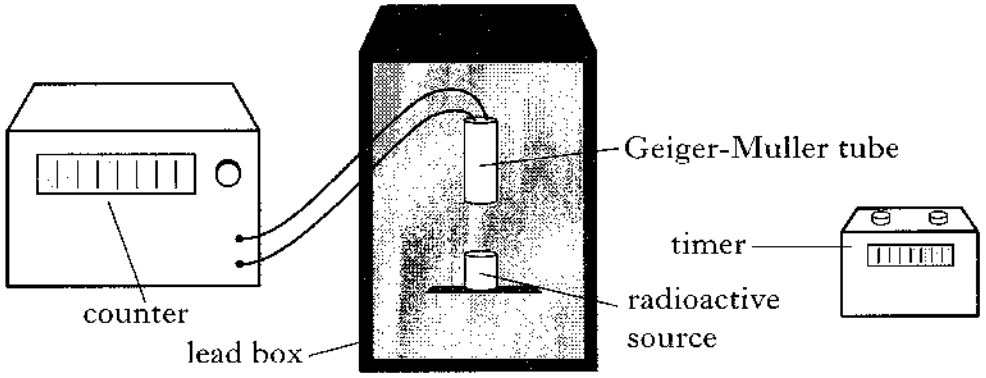
Marks	K&U	PS

7. Radioactive sources are used in medical investigations.

(*a*) A technician uses a Geiger-Muller tube, a counter and a timer to measure the half-life of a radioactive source. The source and the tube are placed in a lead box to exclude background radiation.



(i) Describe how the apparatus is used to measure the half-life of the radioactive source.

.....

.....

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.....

..... **3**

(ii) The half-life of the source is 10 minutes. The initial count rate is 1200 counts per minute.

Calculate the count rate after 40 minutes.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

7. (continued)

Marks | K&U | PS

(*b*) Dose equivalent measures the biological effect of radiation.

(i) What unit is used to measure dose equivalent?

..... **1**

(ii) State **two** factors that dose equivalent depends on.

.....

..... **2**

[Turn over

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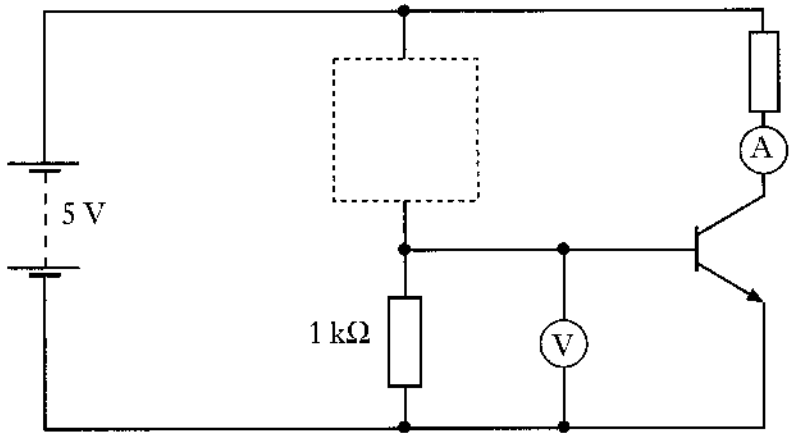
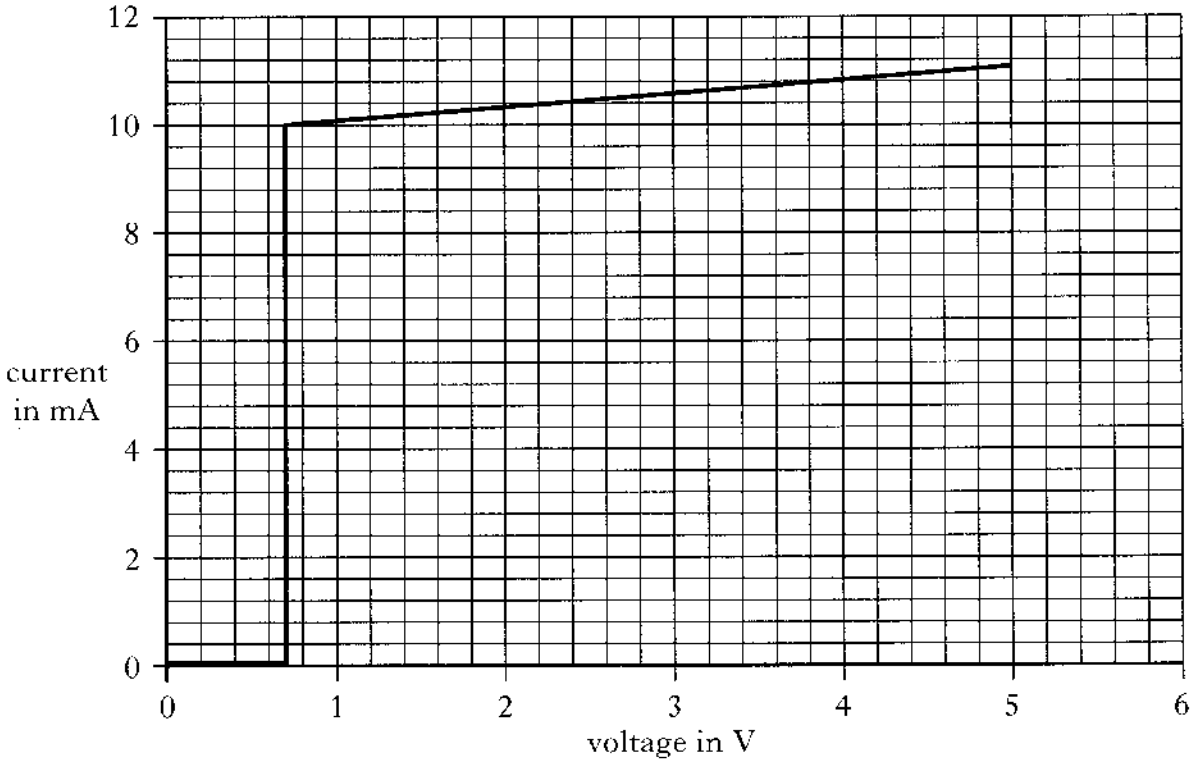
Marks | K&U | PS

8. The circuit shown is used to investigate the switching action of a transistor.



(*a*) Draw the symbol for a variable resistor in the dotted box in the above diagram. **1**

(*b*) The graph shows how the ammeter reading varies with the voltmeter reading when the resistance of the variable resistor is changed.



(i) State the voltage at which the transistor starts to conduct.

..... **1**

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

8. (*b*) (continued)

(ii) Calculate the voltage across the variable resistor when the transistor starts to conduct.

Space for working and answer

1

(iii) Calculate the resistance of the variable resistor when the transistor starts to conduct.

Space for working and answer

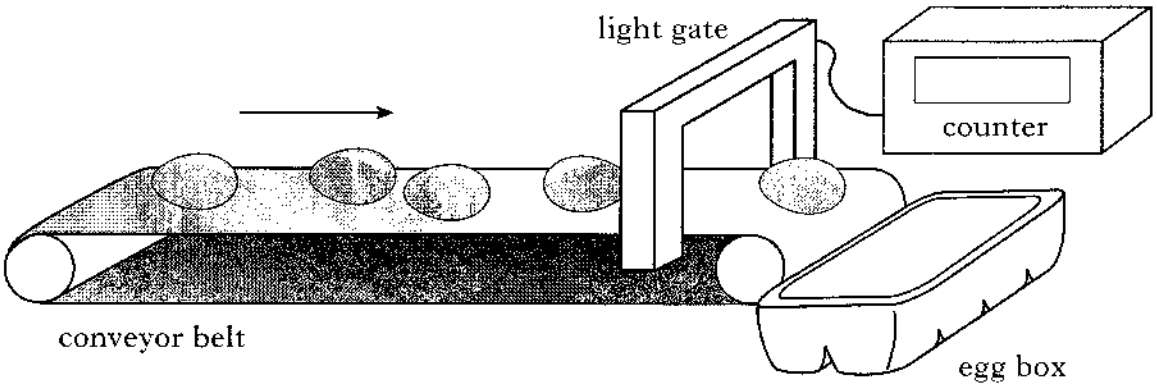
2

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

9. A machine packs eggs into boxes. The eggs travel along a conveyor belt and pass through a light gate that operates a counter. After the correct number of eggs has passed through the light gate, the counter resets and the box is exchanged for an empty one.

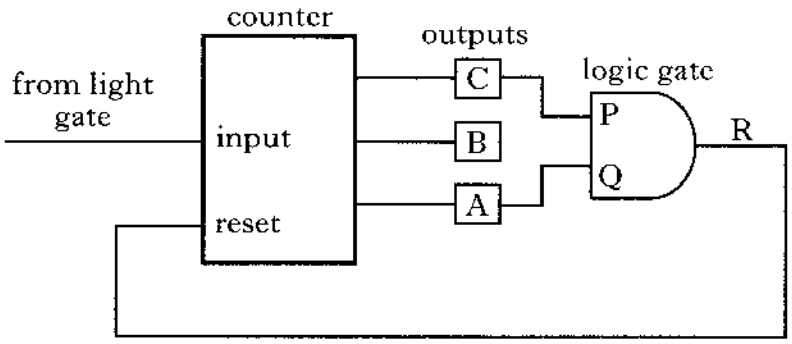


(*a*) The light gate consists of a light source and detector.

State a suitable component to be used as the detector.

..... 1

(*b*) Part of the counter circuit is shown.



The input to the counter goes to logic 1 every time an egg passes through the light gate. When the reset to the counter goes to logic 1, the outputs go to zero.

The table below shows the logic states of the three outputs A, B and C of the counter as eggs pass the detector.

Number of eggs	A	B	C
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

DO NOT WRITE IN THIS MARGIN

Marks | K&U | PS

9. (*b*) (continued)

(i) Complete the truth table for the logic gate shown.

P	Q	R
0	0	
0	1	
1	0	
1	1	

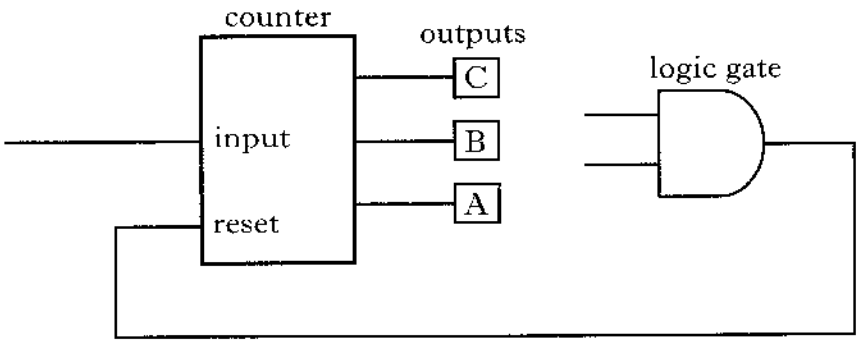
1

(ii) How many eggs are being packed into each box when the logic gate is connected to the counter outputs as shown?

.....

1

(iii) Complete the diagram below to show how the logic gate should be connected to the counter outputs so that six eggs can be packed in a box.



1

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

10. A bobsleigh team competes in a race.

(*a*) Starting from rest, the bobsleigh reaches a speed of 11 m/s after a time of 3·2 s.

Calculate the acceleration of the bobsleigh.

Space for working and answer

2

(*b*) The bobsleigh completes the 1200 m race in a time of 42·0 s.

Calculate the average speed of the bobsleigh.

Space for working and answer

2

(*c*) Describe how the instantaneous speed of the bobsleigh could be measured as it crosses the finish line.

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2

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

10. (continued)

(*d*) To travel as quickly as possible, frictional forces must be minimised. State **two** methods of reducing friction.

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..... 2

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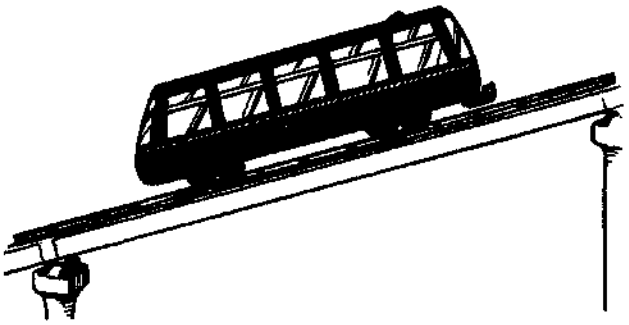
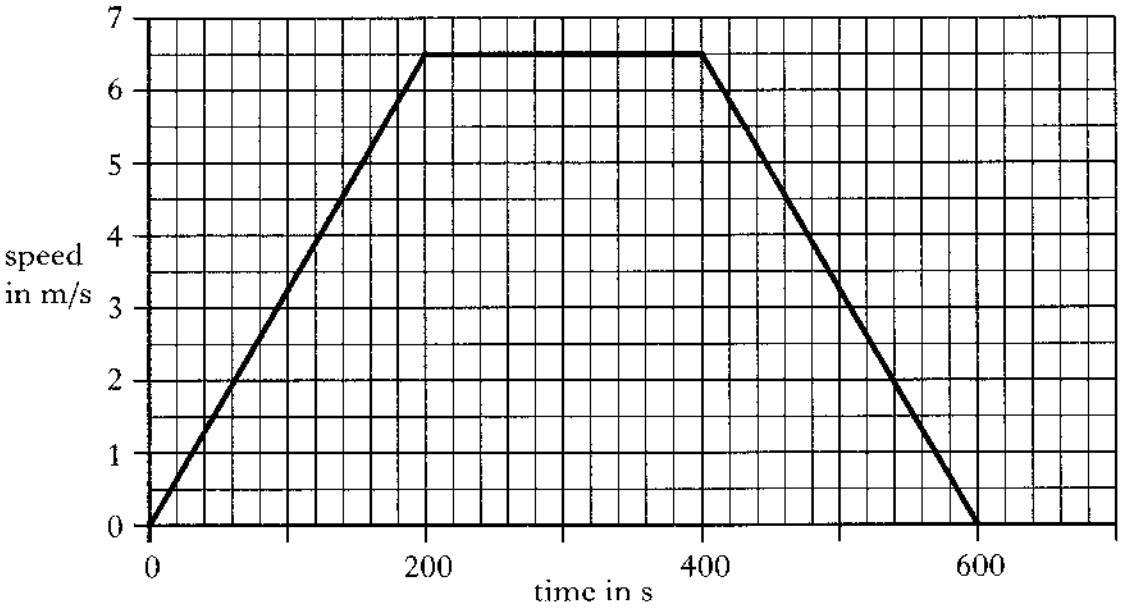
DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

11. A train travels up a mountain carrying skiers in winter and tourists in summer.



(*a*) The graph shows how the speed of the train varies with time for the journey in winter.



(i) Calculate the acceleration of the train during the first 200 s.

Space for working and answer

2

(ii) Calculate the length of the journey.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

Marks | K&U | PS

11. (continued)

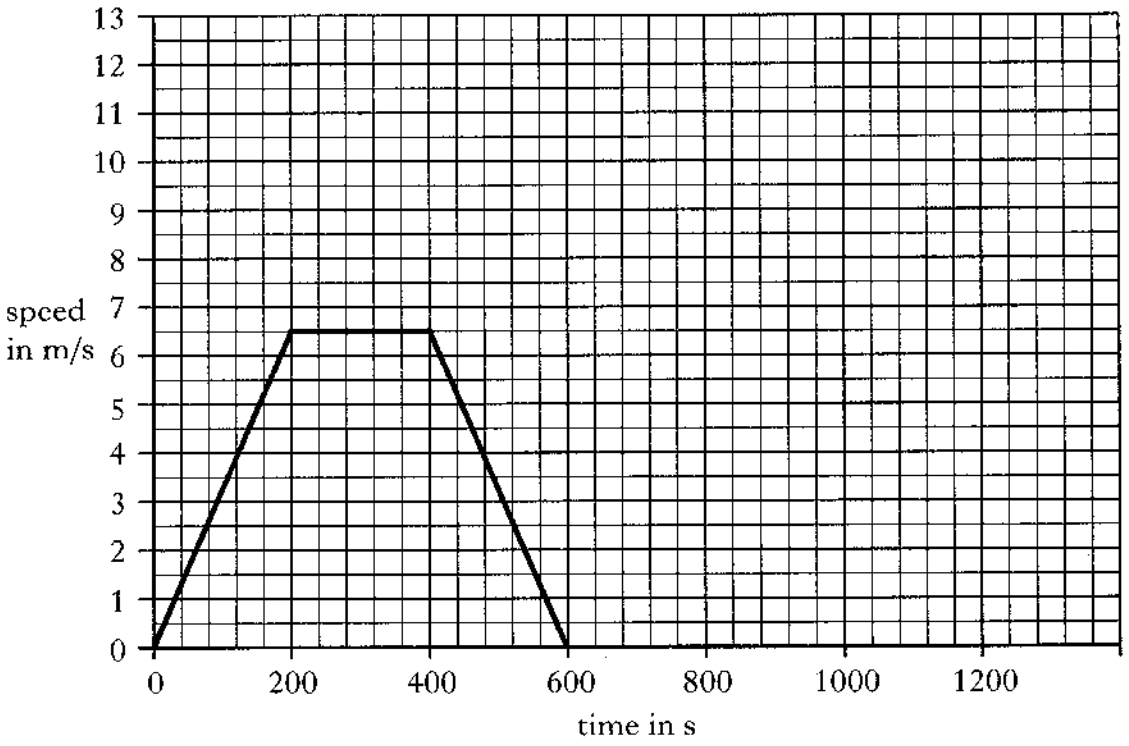
(*b*) The mass of the train is 15 000 kg. During the journey the train travels through a height of 460 m.

Calculate the potential energy gained by the train.

Space for working and answer

2

(*c*) In summer, the train takes a time of 1200 s to travel up the mountain so that tourists can enjoy the view. The acceleration and deceleration of the train remain the same as in winter. The graph below again shows the motion of the train in winter.



Using the axes given above, sketch a second graph showing the motion of the train in summer.
(Calculations are not required.)

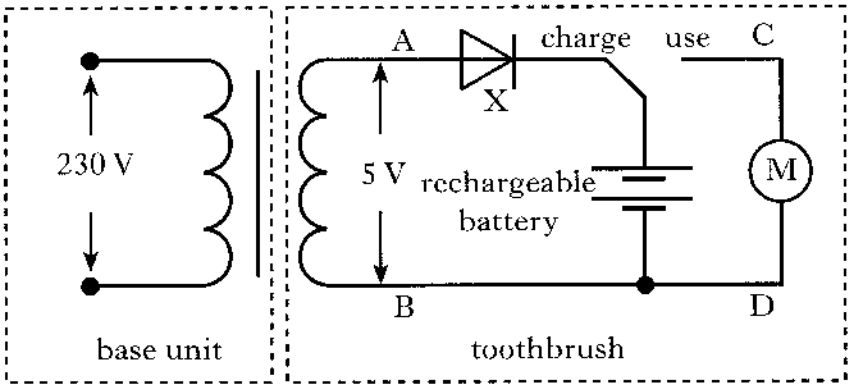
2

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

12. An electric toothbrush contains a rechargeable battery. The battery is recharged using a transformer connected to a 230 V a.c. supply. The primary coil and the core of the transformer are sealed into the base unit. The 5 V secondary coil of the transformer is part of the toothbrush.



To charge the battery, the toothbrush is placed on the base unit, with the switch in the "charge" position.

(*a*) Identify the component labelled X.

.....

1

(*b*) The primary coil of the transformer has 6440 turns.

(i) Assuming the transformer is 100% efficient, calculate the number of turns on the secondary coil.

Space for working and answer

2

(ii) When the toothbrush is charging, the current in the secondary coil is 50 mA.

(A) Calculate the output power of the transformer.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

Marks | K&U | PS

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

(B) In practice, the transformer is only 40% efficient.

Calculate the current in the primary coil.

Space for working and answer

3

(iii) State **one** reason why a transformer is less than 100% efficient.

.....

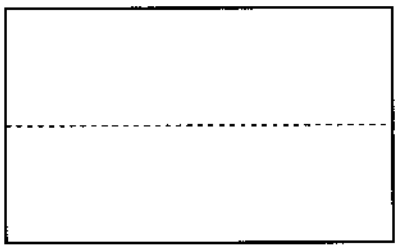
1

(*c*) Sketch the trace seen when an oscilloscope is connected across:

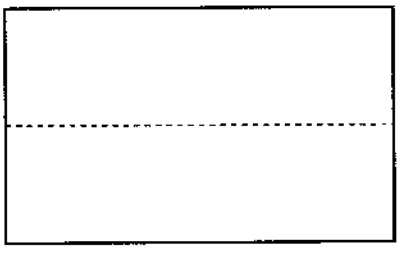
(i) AB when the battery is being charged;

(ii) CD when the toothbrush is removed from the base unit and the switch is in the "use" position.

Values need not be shown on either sketch.



AB



CD

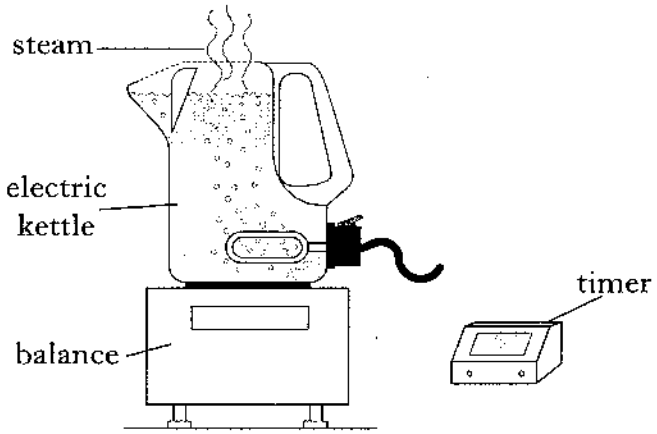
2

[Turn over

DO NOT WRITE IN THIS MARGIN

	Marks	K&U	PS

13. The apparatus shown is used to calculate the value of the specific latent heat of vaporisation of water.



The electric kettle is rated at 3·0 kW. The kettle containing water is placed on the balance. The lid of the kettle is removed and the kettle is switched on. Once the water starts to boil, the kettle is left switched on for a further 85·0 s before being switched off.

(*a*) Calculate how much electrical energy is supplied to the kettle in 85·0 s.

Space for working and answer

2

(*b*) The reading on the balance decreases by 0·12 kg during the 85·0 s.

(i) Assuming all the electrical energy supplied is transferred to the water, calculate the value of the specific latent heat of vaporisation of water obtained in the experiment.

Space for working and answer

2

(ii) The accepted value for the specific latent heat of vaporisation of water is $22{\cdot}6 \times 10^5$ J/kg.

Suggest why there is a difference between this value and the value obtained in (*b*)(i).

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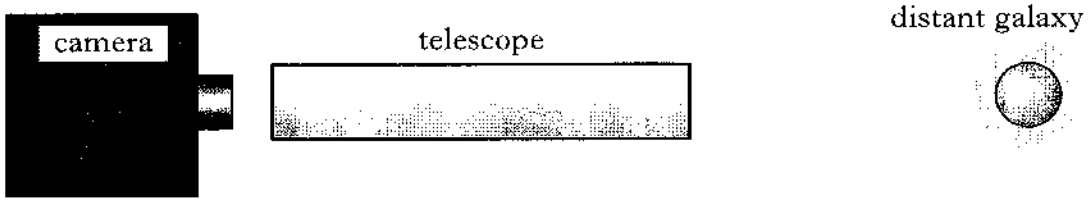
1

DO NOT WRITE IN THIS MARGIN

Marks | K&U | PS

14. An astronomer uses a telescope and a camera to take a photograph of a distant galaxy.



(*a*) The table shows a number of lenses that are available for use in the telescope.

lens	*type*	*focal length* (mm)	*diameter* (mm)
P	concave	15	10
Q	convex	15	10
R	convex	1000	10
S	convex	1000	100
T	concave	1000	100

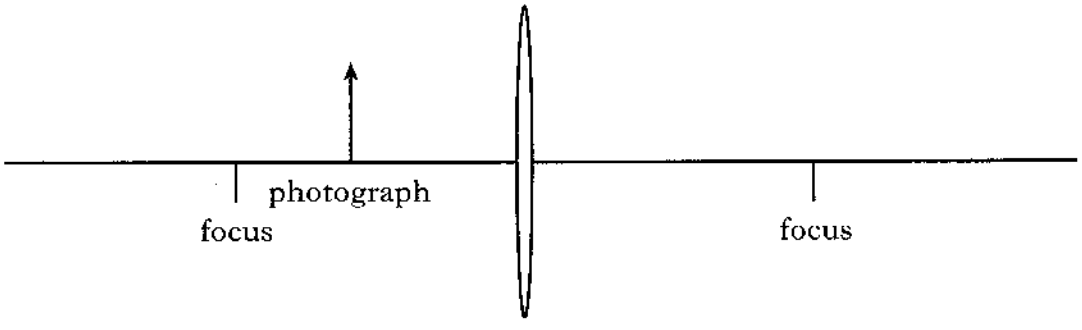
From the table, select the most suitable lenses for use as the eyepiece and the objective of the telescope.

Eyepiece ☐ Objective ☐ 2

(*b*) The astronomer examines the photograph using a magnifying glass.

Complete the ray diagram to show how the magnifying glass can be used to form an image of the photograph.

Your diagram must show the position of the image.



3

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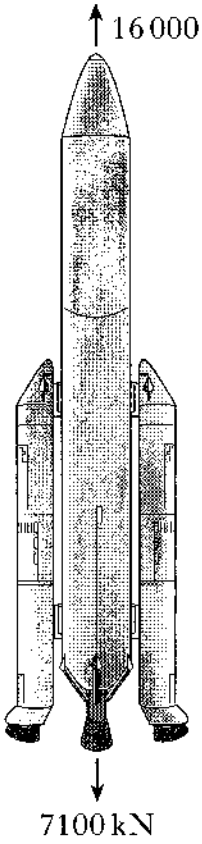
15. A spacecraft consisting of a rocket and a lunar probe is launched from the Earth to the Moon.

(*a*) At lift-off from the Earth, the spacecraft has a weight of 7100 kN. The thrust from the engines is 16 000 kN.



(i) Calculate the unbalanced force acting on the spacecraft.

Space for working and answer

1

(ii) Calculate the mass of the spacecraft.

Space for working and answer

1

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15. (*a*) (continued)

(iii) Calculate the initial acceleration of the spacecraft.

Space for working and answer

2

(*b*) As it approaches the Moon, the probe is detached from the rocket and goes into lunar orbit.

(i) While orbiting the Moon, the probe takes images of the Moon's surface. This data is sent to Earth using radio waves. The distance between the probe and Earth is 384 000 km.

Calculate the time taken for the data to reach Earth.

Space for working and answer

2

(ii) The Moon is a natural satellite and the probe is an artificial satellite.

Explain what a satellite is.

.....

..... 1

(iii) The probe orbits the Moon because of the Moon's gravitational field.

Explain why the probe does not crash into the Moon.

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..... 1

[END OF QUESTION PAPER]

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YOU MAY USE THE SPACE ON THIS PAGE TO REWRITE ANY ANSWER YOU HAVE DECIDED TO CHANGE IN THE MAIN PART OF THE ANSWER BOOKLET. TAKE CARE TO WRITE IN CAREFULLY THE APPROPRIATE QUESTION NUMBER.