FOR OFFICIAL USE

H

National
Qualifications
2018

Mark

X757/76/01

Physics
Section 1 — Answer Grid and Section 2

TUESDAY, 8 MAY

9:00 AM – 11:30 AM

X7577601

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day Month Year

Scottish candidate number

Total marks — 130

SECTION 1 — 20 marks
Attempt ALL questions.
Instructions for the completion of Section 1 are given on *page 02*.

SECTION 2 — 110 marks
Attempt ALL questions.

Reference may be made to the Data Sheet on *page 02* of the question paper X757/76/02 and to the Relationships Sheet X757/76/11.

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

Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. You should score through your rough work when you have written your final copy.

Use **blue** or **black** ink.

Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

X757760101

SECTION 1 — 20 marks

The questions for Section 1 are contained in the question paper X757/76/02.

Read these and record your answers on the answer grid on *page 03* opposite.

Use **blue** or **black** ink. Do NOT use gel pens or pencil.

1. The answer to each question is **either** A, B, C, D or E. Decide what your answer is, then fill in the appropriate bubble (see sample question below).

2. There is **only one correct** answer to each question.

3. Any rough working should be done on the additional space for answers and rough work at the end of this booklet.

Sample question

The energy unit measured by the electricity meter in your home is the

A ampere

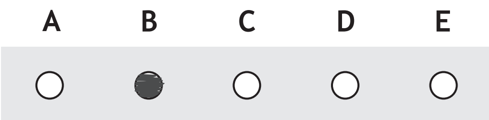
B kilowatt-hour

C watt

D coulomb

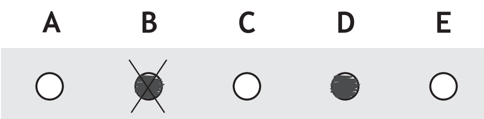
E volt.

The correct answer is **B** — kilowatt-hour. The answer **B** bubble has been clearly filled in (see below).

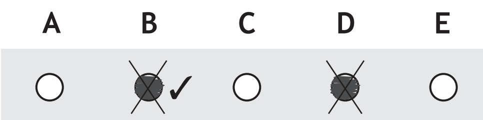


Changing an answer

If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **D**.



If you then decide to change back to an answer you have already scored out, put a tick (✓) to the **right** of the answer you want, as shown below:



or

X757760102

SECTION 1 — Answer Grid

OBJ20AE1

	A	B	C	D	E
1	○	○	○	○	○
2	○	○	○	○	○
3	○	○	○	○	○
4	○	○	○	○	○
5	○	○	○	○	○
6	○	○	○	○	○
7	○	○	○	○	○
8	○	○	○	○	○
9	○	○	○	○	○
10	○	○	○	○	○
11	○	○	○	○	○
12	○	○	○	○	○
13	○	○	○	○	○
14	○	○	○	○	○
15	○	○	○	○	○
16	○	○	○	○	○
17	○	○	○	○	○
18	○	○	○	○	○
19	○	○	○	○	○
20	○	○	○	○	○

X757760103

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X757760104

[Turn over for SECTION 2

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X757760105

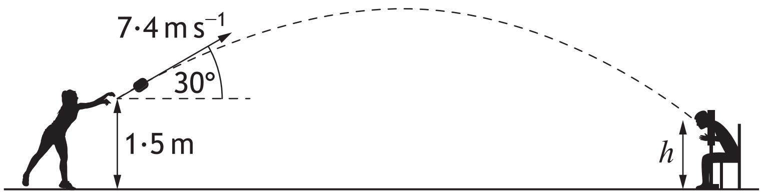
SECTION 2 — 110 marks

Attempt ALL questions

1. During a school funfair, a student throws a wet sponge at a teacher. The sponge is thrown with an initial velocity of $7{\cdot}4\,m\,s^{-1}$ at an angle of 30° to the horizontal.

The sponge leaves the student's hand at a height of $1{\cdot}5\,m$ above the ground.

not to scale



The sponge hits the teacher.

The effects of air resistance can be ignored.

(a) (i) Calculate:

(A) the horizontal component of the initial velocity of the sponge; **1**

Space for working and answer

(B) the vertical component of the initial velocity of the sponge. **1**

Space for working and answer

* X 7 5 7 7 6 0 1 0 6 *

1. (a) (continued)

(ii) Calculate the time taken for the sponge to reach its maximum height. **3**

Space for working and answer

(iii) The sponge takes a further 0·45 s to travel from its maximum height until it hits the teacher.

Determine the height h above the ground at which the sponge hits the teacher. **4**

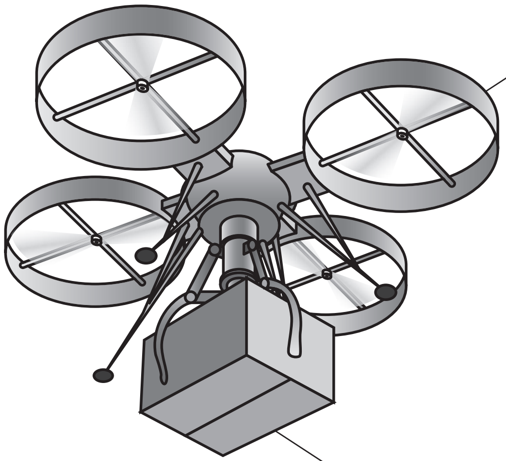
Space for working and answer

(b) The student throwing the sponge makes the following statement.

"If the sponge is thrown with a higher speed at the same angle from the same height then it would take a shorter time to hit the teacher in the same place."

Explain why the student's statement is incorrect. **2**

2. An internet shopping company is planning to use drones to deliver packages.



(a) During a test the drone is hovering at a constant height above the ground.

The mass of the drone is 5·50 kg.

The mass of the package is 1·25 kg.

(i) Determine the upward force produced by the drone. **3**

Space for working and answer

2. (a) (continued)

(ii) The package is now lowered using a motor and a cable.

A battery supplies 12 V across the motor. The resistance of the motor is 9·6 Ω.

Calculate the power dissipated by the motor. **3**

Space for working and answer

(iii) While the package is being lowered the cable breaks.

The upward force produced by the drone remains constant.

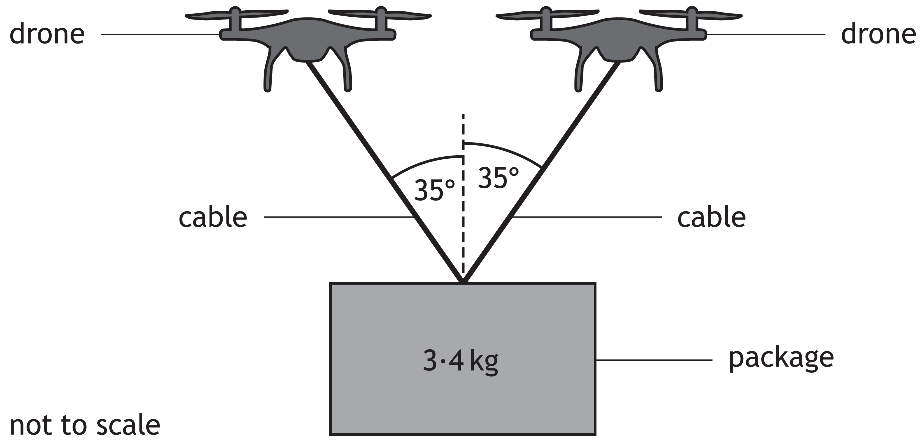
Describe the vertical motion of the drone immediately after the cable breaks. **2**

Justify your answer.

[Turn over

2. (continued)

(b) To carry a package with a greater mass two drones are used as shown.



The drones are hovering at a constant height above the ground.

The mass of the package suspended from the two drones is 3·4 kg.

Determine the tension in each cable. **4**

Space for working and answer

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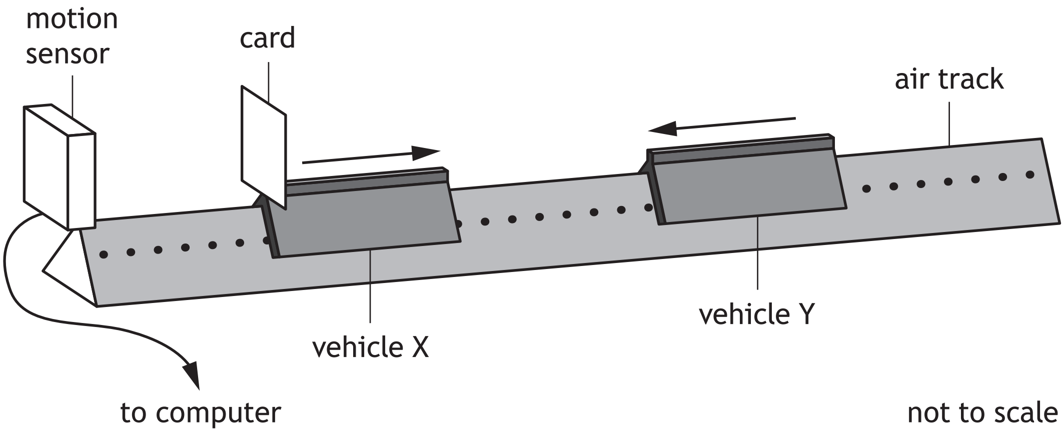
3. A student sets up an experiment to investigate a collision between two vehicles on a frictionless air track.

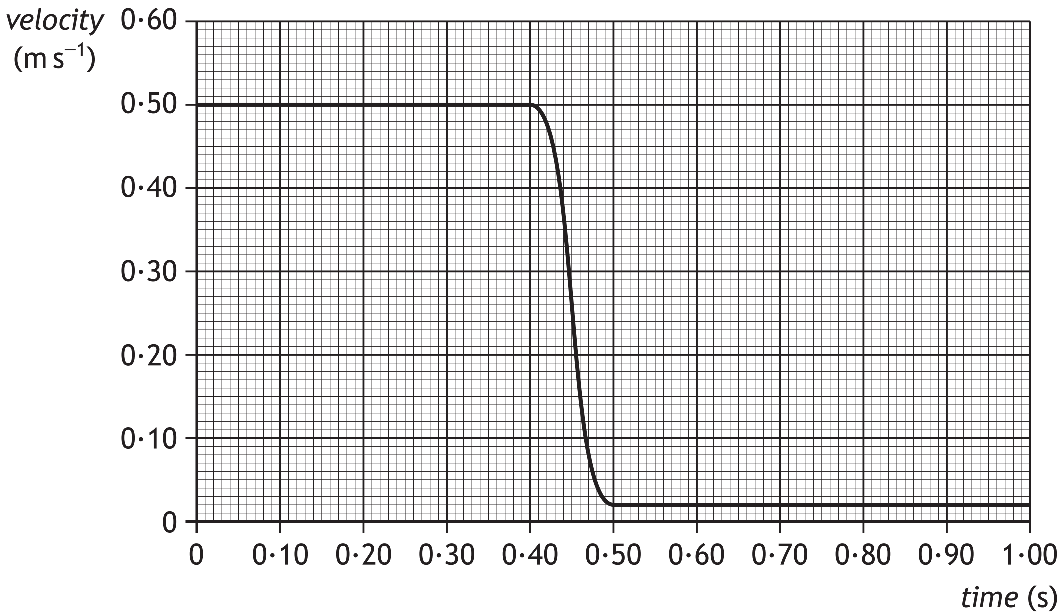


Vehicle X of mass 0·75 kg is travelling to the right along the track.

Vehicle Y of mass 0·50 kg is travelling to the left along the track with a speed of 0·30 m s^{-1}.

The vehicles collide and move off separately.

A computer displays a graph showing the velocity of vehicle X from just before the collision to just after the collision.



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3. (continued)

(a) Show that the velocity of vehicle Y after the collision is $0{\cdot}42\,m\,s^{-1}$. **2**

Space for working and answer

(b) Determine the impulse on vehicle Y during the collision. **3**

Space for working and answer

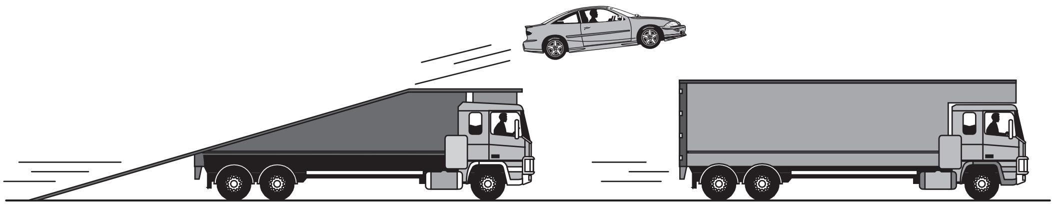
[Turn over

3. (continued)

(c) Explain how the student would determine whether the collision was elastic or inelastic. **2**

4. A stunt is being carried out during the making of a film.

A car is to be driven up a ramp on a moving lorry by a stunt driver, who will attempt to land the car safely on the roof of a second moving lorry. The car is to stop on the roof of the second lorry while this lorry is still moving.



Using your knowledge of physics, comment on the challenges involved in carrying out the stunt successfully. **3**

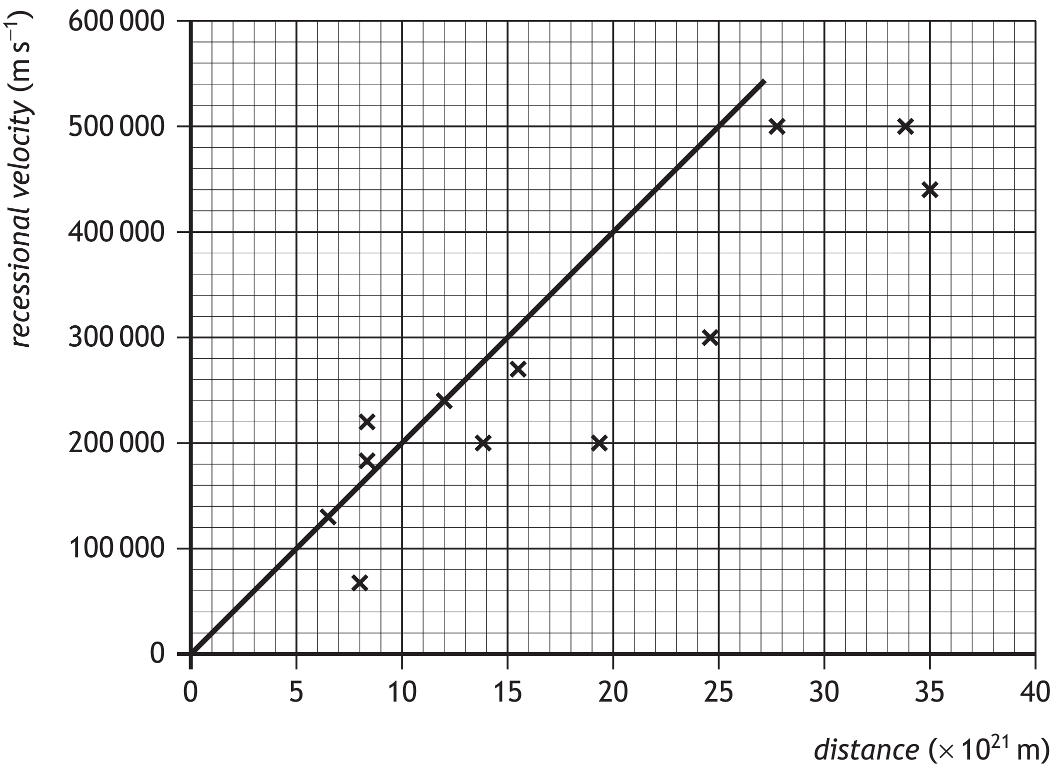
[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

5. Hubble's Law states that the universe is expanding. The expanding universe is one piece of evidence that supports the Big Bang theory.

(a) State one other piece of evidence that supports the Big Bang theory. **1**

(b) A student plots some of the original data from the 1929 paper by Edwin Hubble and adds the line shown in order to determine a value for the Hubble constant H_0.



The student calculates the gradient of their line and obtains a value for the Hubble constant of $2{\cdot}0 \times 10^{-17}\,s^{-1}$.

The age of the universe can be calculated using the relationship

$$\text{age of universe} = \frac{1}{H_0}$$

5. (b) (continued)

(i) Calculate the age of the universe, in years, obtained when using the student's value for the Hubble constant. **2**

Space for working and answer

(ii) The current estimate for the age of the universe is $13 \cdot 8 \times 10^{9}$ years.

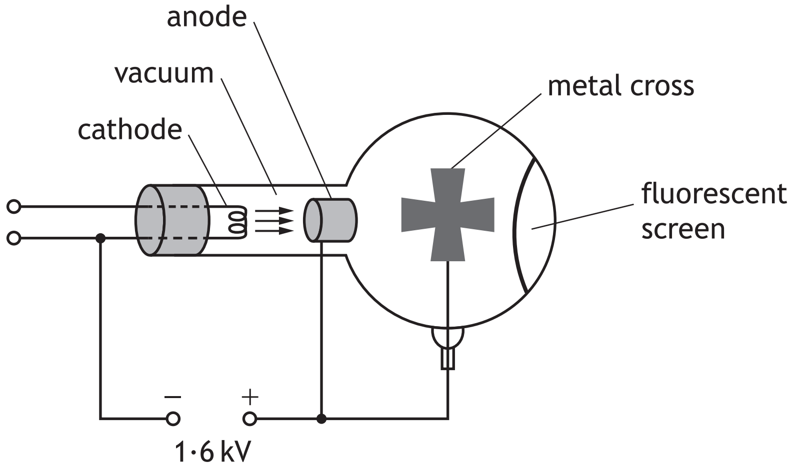
(A) State why the value obtained in (b)(i) is different from the current estimate for the age of the universe. **1**

(B) Suggest a change that the student could make to their graph to obtain a value closer to the current estimate for the age of the universe. **1**

(c) It has been discovered that the rate of expansion of the universe is increasing.

State what physicists think is responsible for this increase. **1**

6. An experiment is set up to demonstrate a simple particle accelerator.



(a) Electrons are accelerated from rest between the cathode and the anode by a potential difference of 1·6 kV.

(i) Show that the work done in accelerating an electron from rest is $2{\cdot}6 \times 10^{-16}$ J. **2**

Space for working and answer

(ii) Calculate the speed of the electron as it reaches the anode. **3**

Space for working and answer

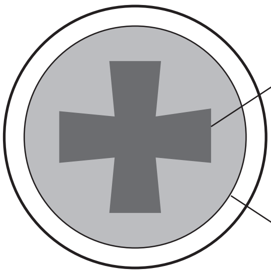
6. (continued)

(b) As the electrons travel through the vacuum towards the fluorescent screen they spread out.

In the path of the electrons there is a metal cross, which is connected to the positive terminal of the supply. The electrons that hit the cross are stopped by the metal.

Electrons that get past the metal cross hit a fluorescent screen at the far side of the tube.

When electrons hit the fluorescent screen, the screen glows.



The potential difference between the anode and the cathode is now increased to 2·2 kV. This changes what is observed on the screen.

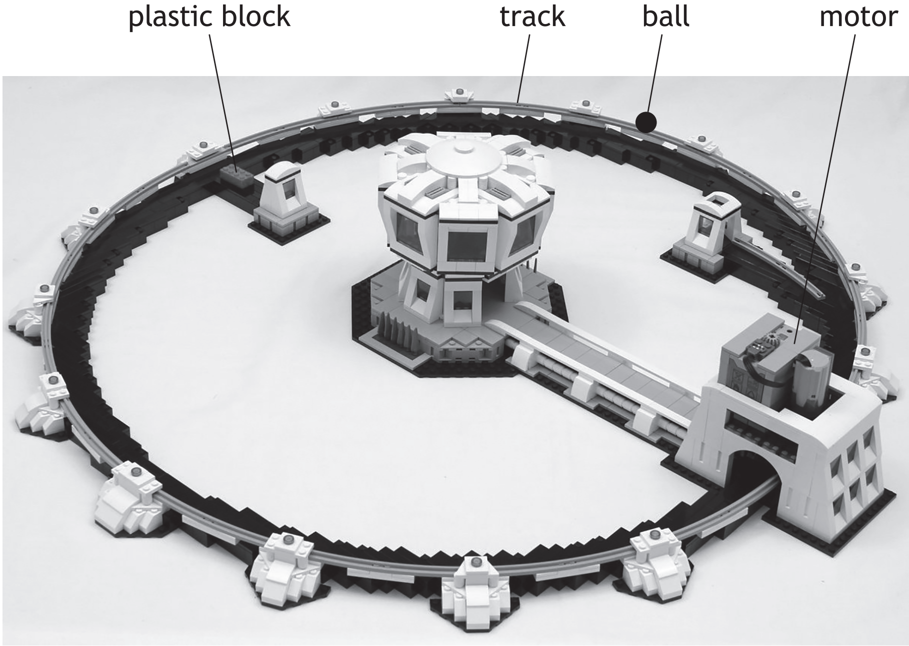
Suggest one change that is observed. **2**

You must justify your answer.

[Turn over

6. **(continued)**

(c) A student builds a model of a particle accelerator. The model accelerates a small ball on a circular track. A battery-operated motor accelerates the ball each time it passes the motor. To cause a collision a plastic block is pushed onto the track. The ball then hits the block.



Using your knowledge of physics comment on the model compared to a real particle accelerator, such as the large hadron collider at CERN. **3**

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6. (c) (continued)

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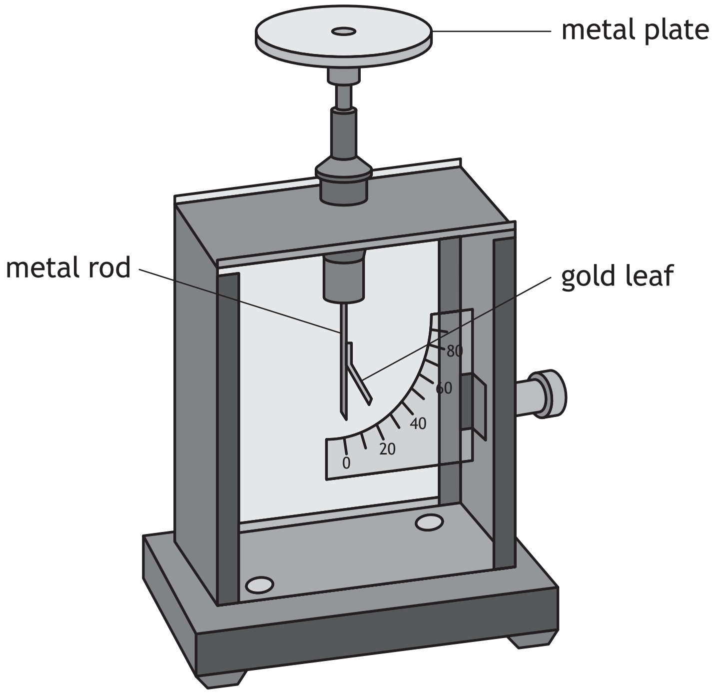
7. A student uses a gold-leaf electroscope to investigate the photoelectric effect. A deflection of the gold leaf on the electroscope shows that the metal plate is charged.

The student charges the metal plate on the electroscope and the gold leaf is deflected.



gold-leaf electroscope

(a) Ultraviolet light is shone onto the negatively charged metal plate. The gold-leaf electroscope does not discharge. This indicates that photoelectrons are not ejected from the surface of the metal.

Suggest one reason why photoelectrons are not ejected from the surface of the metal. **1**

7. (continued)

(b) The student adjusts the experiment so that the gold-leaf electroscope now discharges when ultraviolet light is shone onto the plate.

The work function for the metal plate is $6 \cdot 94 \times 10^{-19}$ J.

(i) State what is meant by a *work function of* $6 \cdot 94 \times 10^{-19}$ *J*. **1**

(ii) The irradiance of the ultraviolet light on the metal plate is reduced by increasing the distance between the gold-leaf electroscope and the ultraviolet light source.

State what effect, if any, this has on the maximum kinetic energy of the photoelectrons ejected from the surface of the metal. **2**

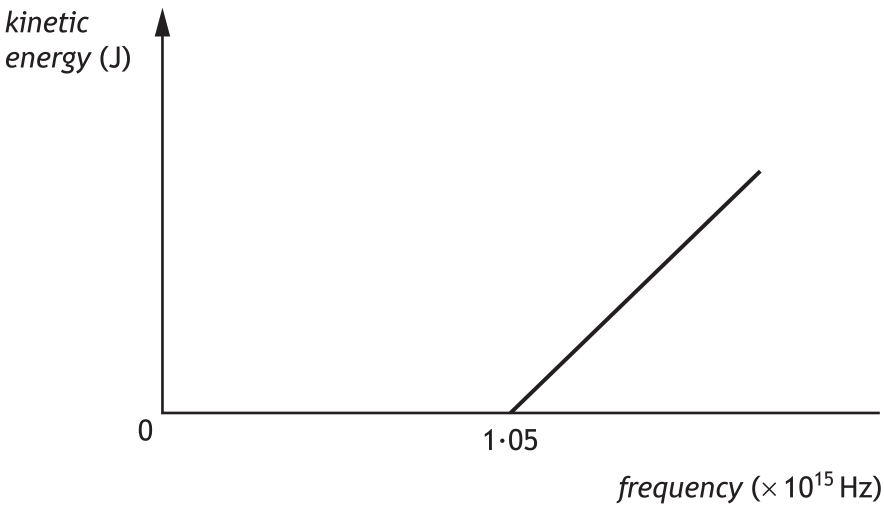
Justify your answer.

[Turn over

7. (continued)

(c) The graph shows how the kinetic energy of the photoelectrons ejected from the metal plate varies as the frequency of the incident radiation increases.

The threshold frequency for the metal plate is $1 \cdot 05 \times 10^{15}$ Hz.



The metal plate is now replaced with a different metal plate made of aluminium.

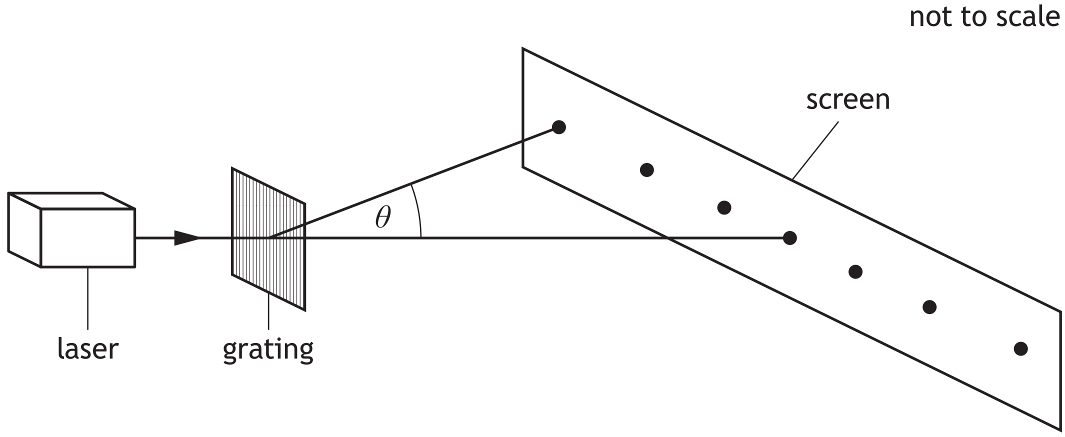
The aluminium has a threshold frequency of $0 \cdot 99 \times 10^{15}$ Hz.

Add a line to the graph to show how the kinetic energy of the photoelectrons ejected from the aluminium plate varies as the frequency of the incident radiation increases. **2**

(An additional graph, if required, can be found on *page 45*.)

(d) Explain why the photoelectric effect provides evidence for the particle nature of light. **1**

8. A student investigates interference of light by directing laser light of wavelength 630 nm onto a grating as shown.



(a) A pattern of bright spots is observed on a screen.

(i) Explain, in terms of waves, how bright spots are produced on the screen. **1**

(ii) The grating has 250 lines per millimetre.

Calculate the angle θ between the central maximum and the third order maximum. **3**

Space for working and answer

[Turn over

8. (a) (continued)

(iii) The grating is now replaced by one which has 600 lines per millimetre.

State the effect of this change on the pattern observed. **2**

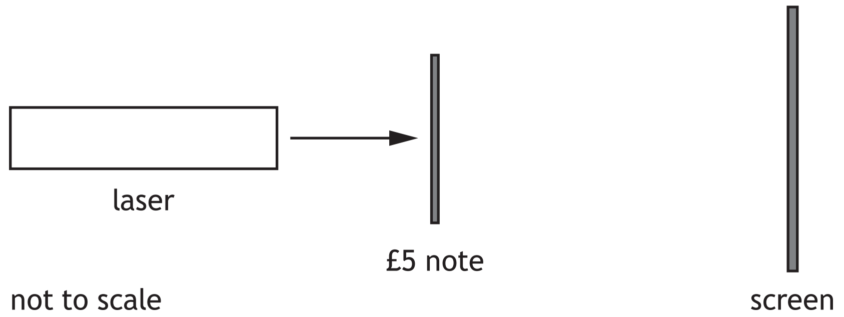
Justify your answer.

(iv) The interference pattern is produced by coherent light.

State what is meant by the term *coherent*. **1**

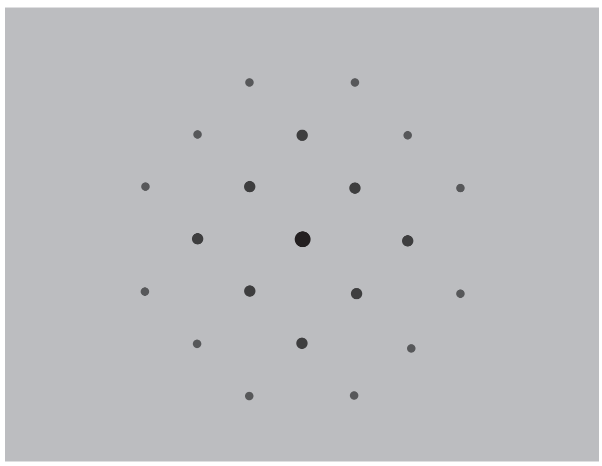
8. (continued)

(b) The student now shines light from the laser onto a £5 note.



When it is shone through the transparent section of the note the student observes a pattern of bright spots on the screen.

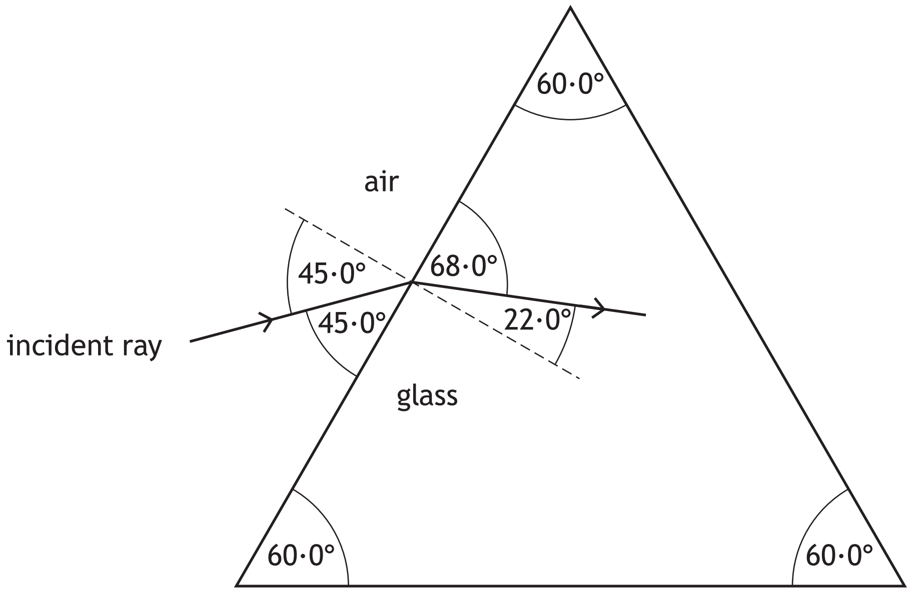
The diagram below shows the pattern that the student observes on the screen.



Suggest a reason for the difference in the pattern produced using the £5 note and the pattern produced using the grating. **1**

[Turn over

9. A ray of monochromatic light is incident on a glass prism as shown.



(a) Show that the refractive index of the glass for this ray of light is 1·89. **2**

Space for working and answer

(b) (i) State what is meant by the term *critical angle*. **1**

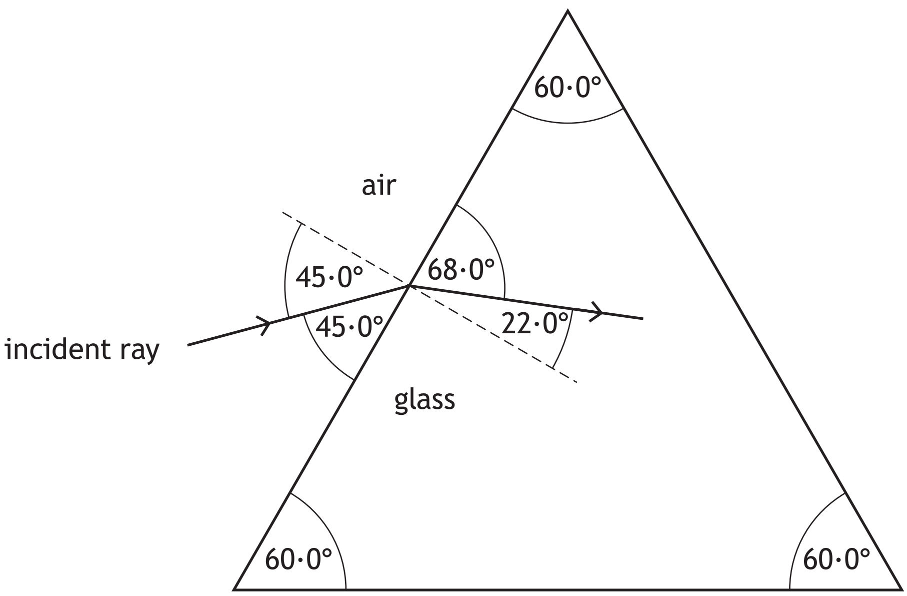
9. (b) (continued)

(ii) Calculate the critical angle for this light in the prism. **3**

Space for working and answer

(iii) Complete the diagram below to show the path of the ray as it passes through the prism and emerges into the air.

Mark on the diagram the values of all relevant angles. **4**

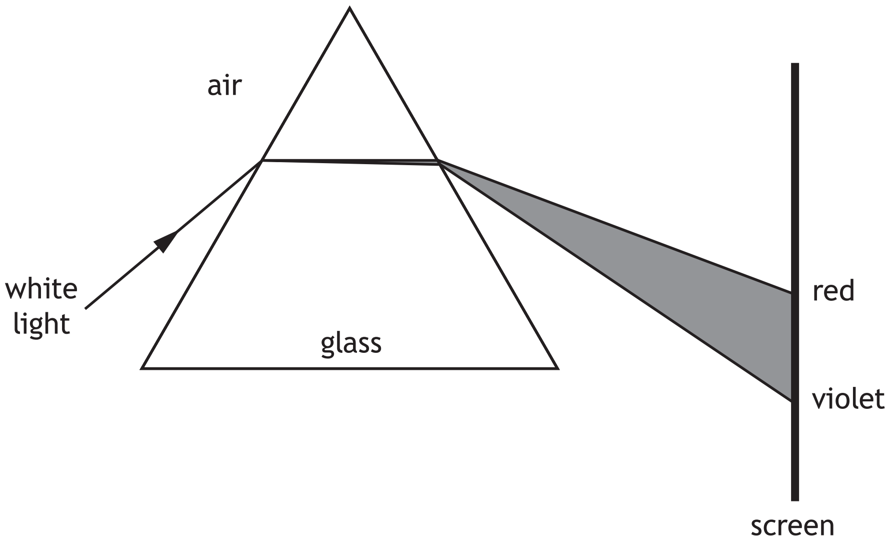


(An additional diagram, if required, can be found on *page 45*.)

[Turn over

9. (continued)

(c) A ray of white light is shone through the prism and a spectrum is observed as shown.



The prism is now replaced with another prism made from a different type of glass with a lower refractive index.

Describe one difference in the spectrum produced by this prism compared to the spectrum produced by the first prism. **1**

10. In a laboratory experiment, light from a hydrogen discharge lamp is used to produce a line emission spectrum. The line spectrum for hydrogen has four lines in the visible region as shown.

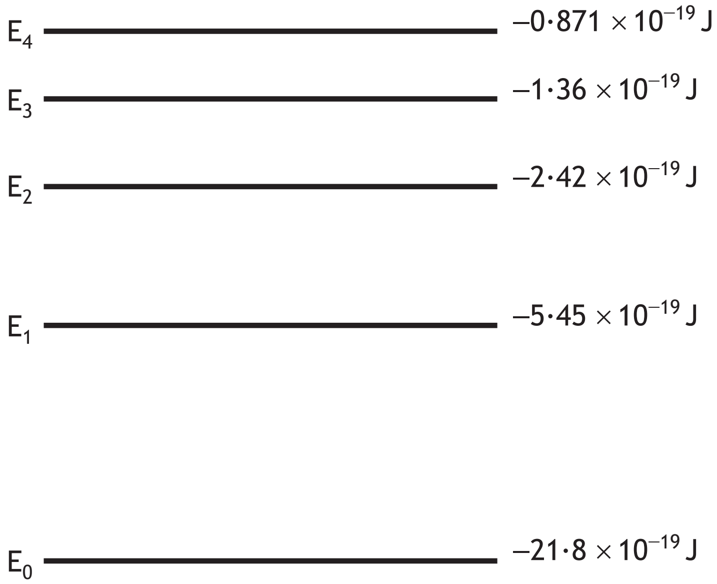
(a) The production of the line spectrum can be explained using the Bohr model of the atom.

State **two** features of the *Bohr model* of the atom. **2**

[Turn over

10. (continued)

(b) Some of the energy levels of the hydrogen atom are shown.



One of the spectral lines is due to electron transitions from E_3 to E_1.

Determine the frequency of the photon emitted when an electron makes this transition. **3**

Space for working and answer

10. (continued)

(c) In the laboratory, a line in the hydrogen spectrum is observed at a wavelength of 656 nm.

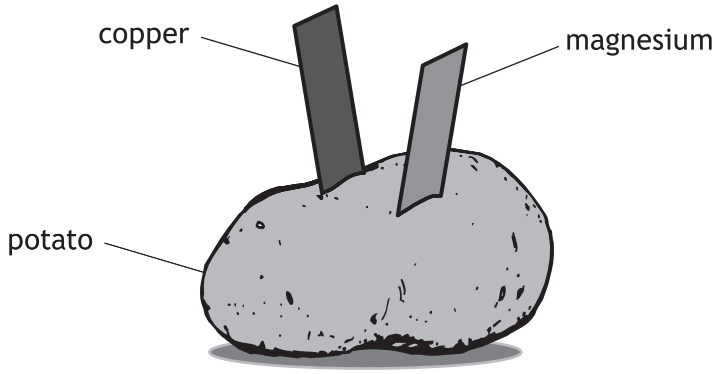
When the spectrum of light from a distant galaxy is viewed, this hydrogen line is now observed at a wavelength of 661 nm.

Determine the recessional velocity of the distant galaxy. **5**

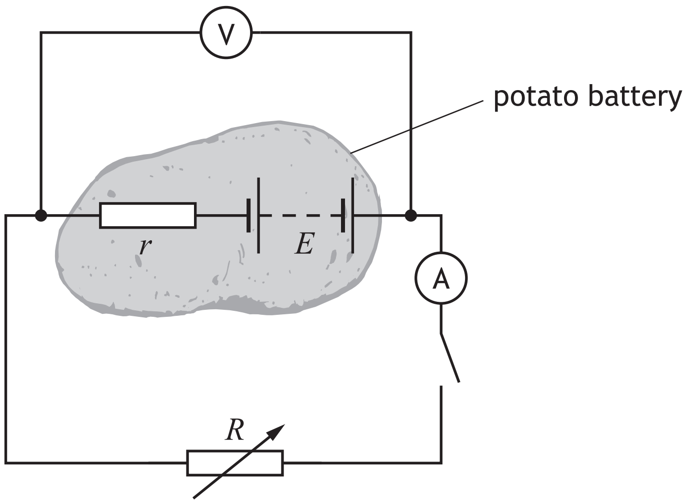
Space for working and answer

[Turn over

11. A student constructs a battery using a potato, a strip of copper and a strip of magnesium.



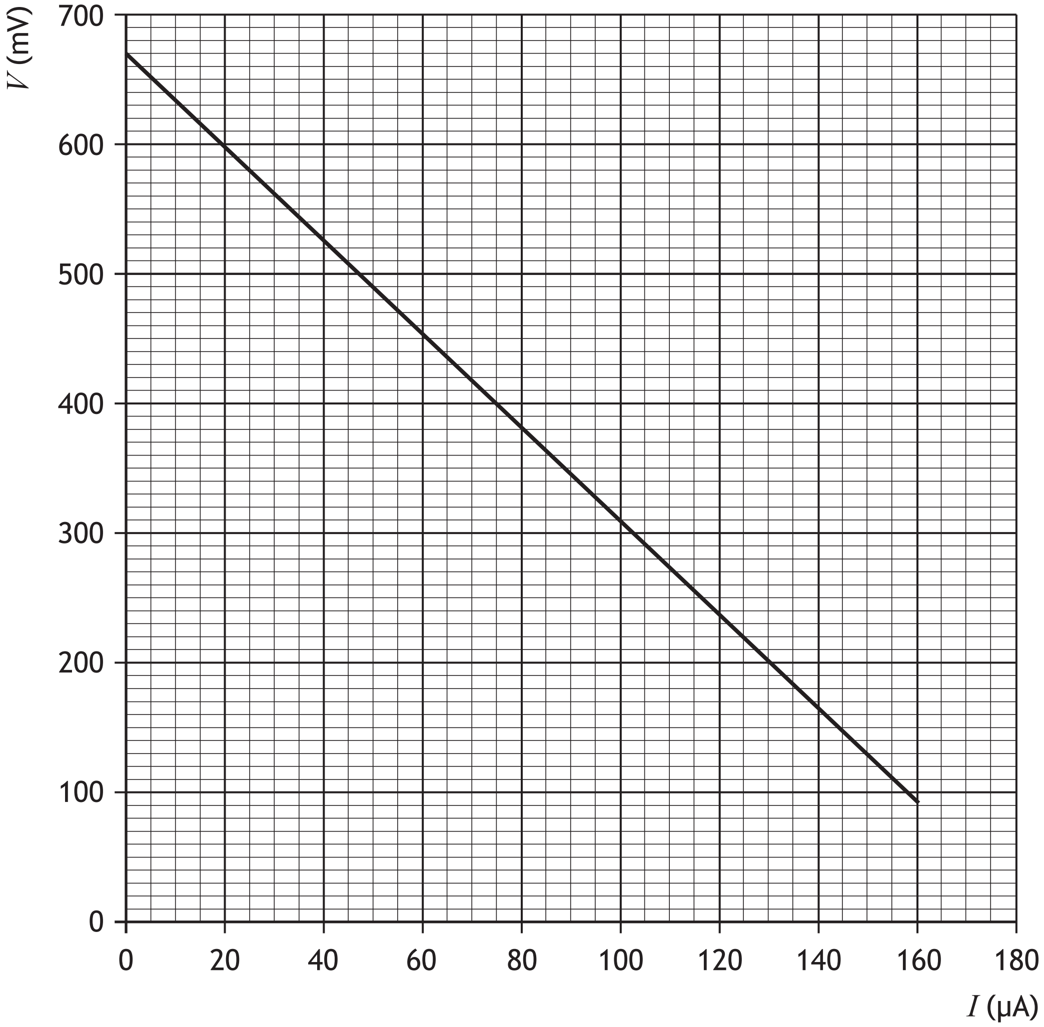
The student then sets up the following circuit with the potato battery connected to a variable resistor R, in order that the electromotive force (e.m.f.) and internal resistance of the battery may be determined.



(a) State what is meant by the term *electromotive force* (*e.m.f.*). **1**

11. (continued) MARKS | DO NOT WRITE IN THIS MARGIN

(b) The student uses readings of current I and terminal potential difference V from this circuit to produce the graph shown.



Determine the internal resistance of the potato battery. **3**

Space for working and answer

[Turn over

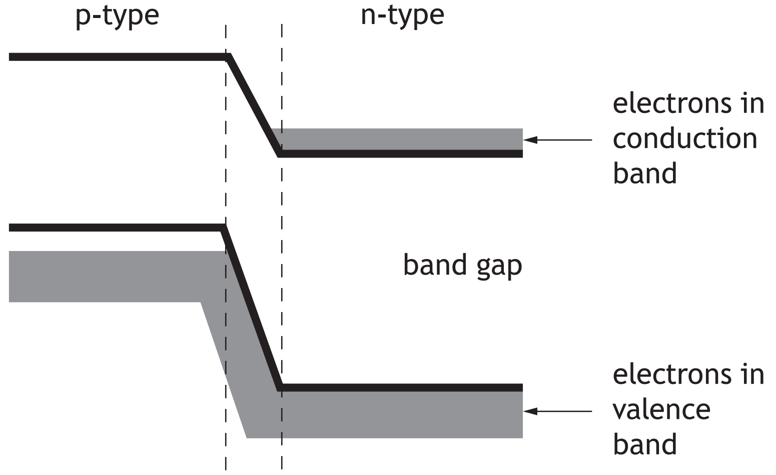
11. (continued)

(c) The student connects a red LED and a blue LED, in turn, to the battery.

The LEDs are forward biased when connected.

The student observes that the battery will operate the red LED but not the blue LED.

The diagram represents the band structure of the blue LED.



LEDs emit light when electrons fall from the conduction band into the valence band of the p-type semiconductor.

Explain, using **band theory**, why the blue LED will not operate with this battery. **1**

[Turn over for next question

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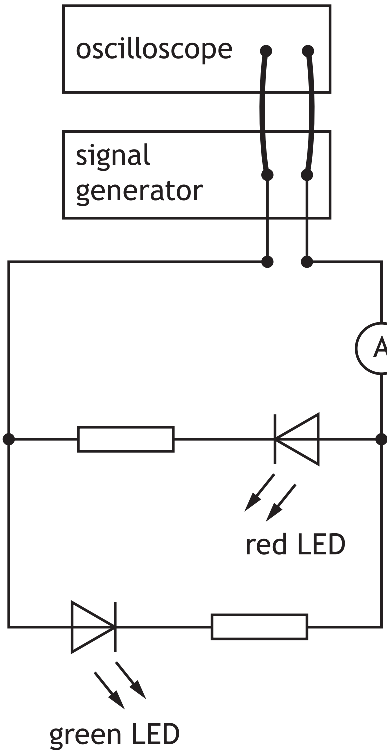
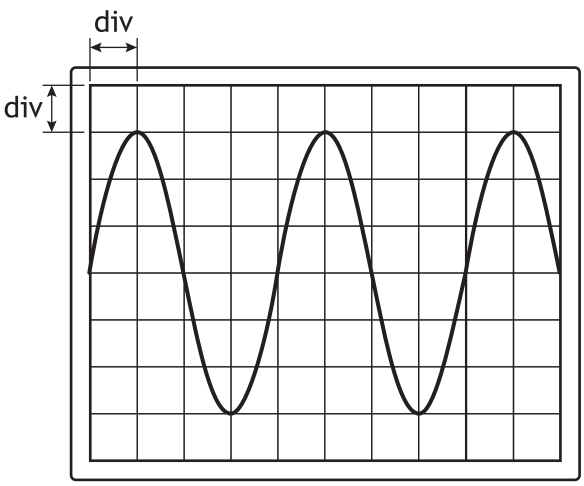
12. A student carries out a series of experiments to investigate alternating current.

(a) A signal generator is connected to an oscilloscope and a circuit as shown.



The output of the signal generator is displayed on the oscilloscope.



The Y-gain setting on the oscilloscope is 1·0 V/div.

The timebase setting on the oscilloscope is 0·5 s/div.

* X 7 5 7 7 6 0 1 3 8 *

12. (a) (continued)

(i) Determine the peak voltage of the output of the signal generator. **1**

Space for working and answer

(ii) Determine the frequency of the output of the signal generator. **3**

Space for working and answer

(iii) The student observes that the red LED is only lit when the ammeter gives a positive reading and the green LED is only lit when the ammeter gives a negative reading.

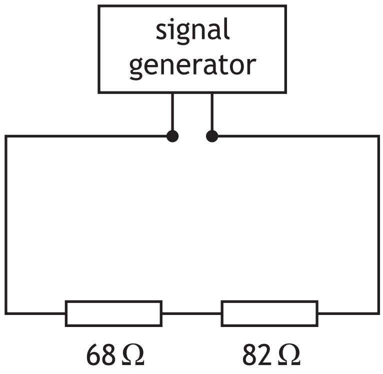
Explain these observations. **2**

12. (continued)

(b) The signal generator is now connected in a circuit as shown.

The settings on the signal generator are unchanged.

The signal generator has negligible internal resistance.

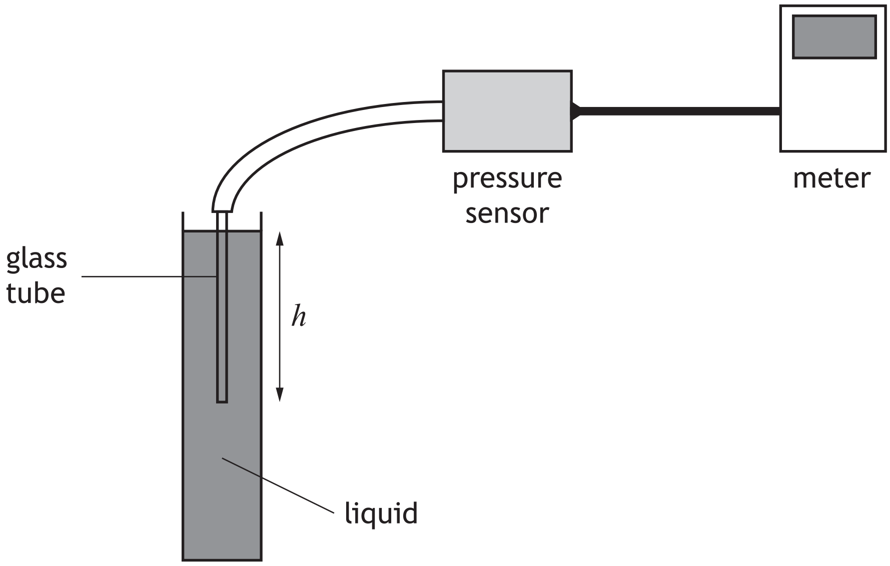


Determine the r.m.s. voltage across the 82 Ω resistor. **5**

Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

13. A student sets up an experiment to investigate the pressure due to a liquid as shown.



The pressure due to a liquid is given by the relationship

$$p = \rho g h$$

where p is the pressure due to the liquid in pascals (Pa),

g is the gravitational field strength in $N\,kg^{-1}$,

ρ is the density of the liquid in $kg\,m^{-3}$,

and h is the depth in the liquid in m.

(a) The student initially carries out the investigation using water.

The density of water is $1{\cdot}00 \times 10^3\,kg\,m^{-3}$.

Calculate the pressure due to the water at a depth of $0{\cdot}35\,m$. **2**

Space for working and answer

* X 7 5 7 7 6 0 1 4 1 *

13. (continued)

(b) The student repeats the experiment with a different liquid.

The pressure meter is set to zero before the glass tube is lowered into the liquid.

The student takes measurements of the pressure at various depths below the surface of the liquid.

The student records the following information.

Depth, h (m)	Pressure, p (kPa)
0·10	1·2
0·20	2·5
0·30	3·6
0·40	4·9
0·50	6·2

(i) Using the square-ruled paper on *page 43*, draw a graph of p against h. **3**

(Additional graph paper, if required, can be found on *page 44*.)

(ii) Calculate the gradient of your graph. **2**

Space for working and answer

(iii) Determine the density of this liquid. **2**

Space for working and answer

[END OF QUESTION PAPER]

* X 7 5 7 7 6 0 1 4 2 *

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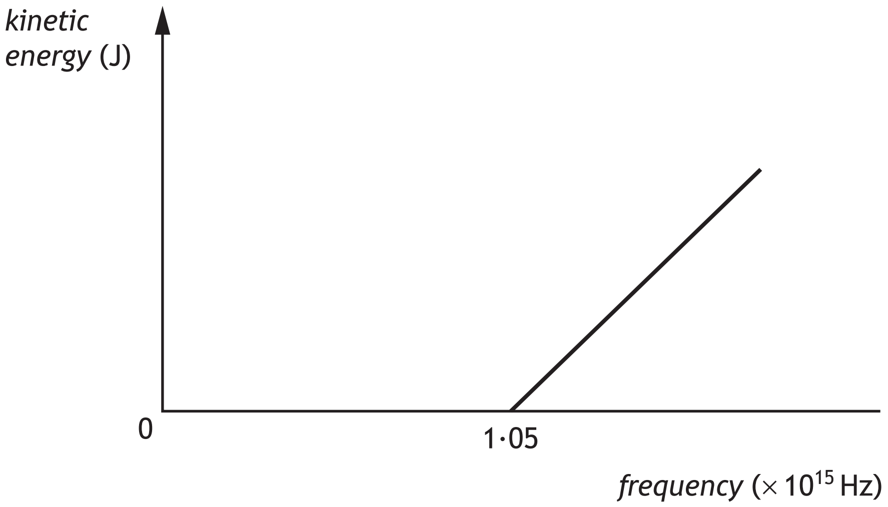
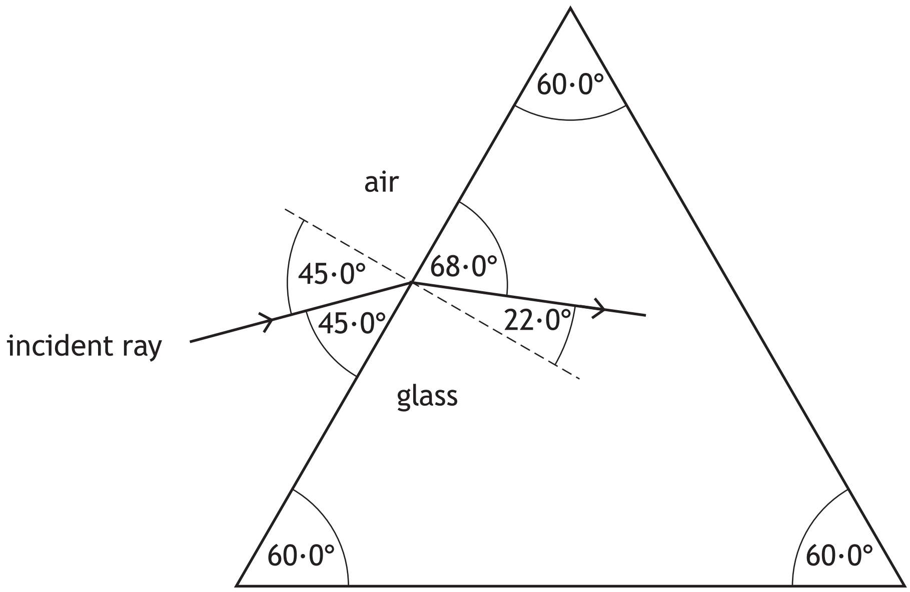
ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

Additional graph for use with Question 7 (c)



Additional diagram for use with Question 9 (b) (iii)



MARKS DO NOT WRITE IN THIS MARGIN

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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MARKS DO NOT WRITE IN THIS MARGIN

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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ACKNOWLEDGEMENTS

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