3220/402

32203101

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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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

K&U | PS

1. A mountain climber carries a device which receives radio signals from satellites to determine the climber's position.

The device can also be used to send the climber's position to the emergency services in the event of an accident.

emergency
alert button
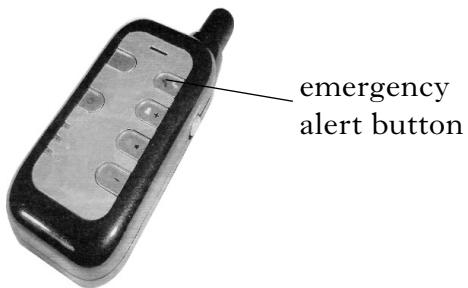
(*a*) One satellite sends a radio signal that is received by the device 0·068 s after transmission.

   (i) State the speed of the radio signal.

   .... **1**

   (ii) Calculate the distance between this satellite and the climber.

   ┌───┐
   │ *Space for working and answer*   │
   │   │
   │   │
   │   │
   │   │
   │   │
   │   │
   │   │
   │   **2**│
   └───┘

1. (continued)

(*b*) The device sends a radio signal to the emergency services.

The frequency of the signal is 2100 MHz.

Calculate the wavelength of this signal.

Space for working and answer

2

(*c*) The emergency services use a telephone to contact the nearest mountain rescue team.

A student examines the electrical signal from a telephone mouthpiece. An oscilloscope is connected to the mouthpiece and displays an electrical signal when the student whistles into the mouthpiece.

P
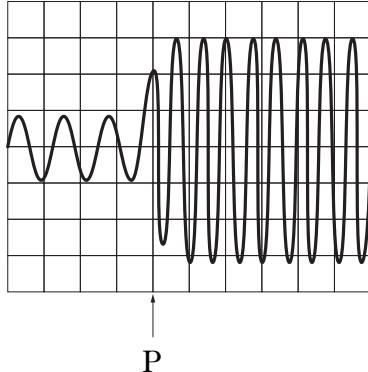
State and describe what happens at point P on the signal pattern to:

A   the loudness of the sound;

    ....

    ....   **1**

B   the frequency of the sound.

    ....

    ....   **1**

2. A rugby match is being played at Murrayfield. Spectators are able to view close-up images and replays of the match on giant screens.

(*a*) Each screen is composed of millions of clusters of LEDs. The diagram below shows one of these clusters.

A cluster of LEDs

Red

Green Blue
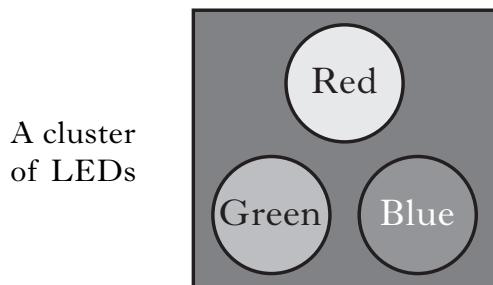
(i) In one cluster all LEDs are switched on.

State the colour observed on the screen in this area.

.... **1**

(ii) The green LED in this cluster is now switched off.

What colour is observed?

.... **1**

2. (continued)

(*b*) The LED screens are controlled by a computer which receives images from pitch-side cameras.

The computer is linked to the screens using optical fibres.

(i) Describe how signals are transmitted along optical fibres.

....

....

.... **2**

(ii) State **one** advantage of using optical fibres rather than copper wires for transmitting the signals.

....

.... **1**

[Turn over

3. A mains electric fire has two heating elements which can be switched on and off separately. The heating elements can be switched on to produce three different heat settings: LOW, MEDIUM and HIGH. The fire also has an interior lamp which can be switched on to give a log-burning effect.

The circuit diagram for the fire is shown.

230 V
mains supply

60 W   **S1**

46 Ω   **S2**

heating element
92 Ω   **S3**

heating element
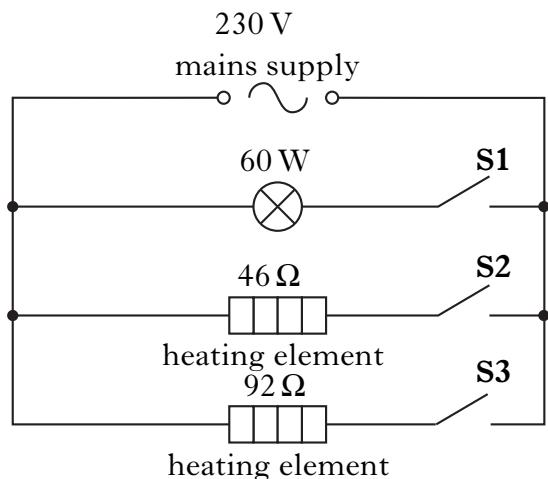
(*a*) When switch **S1** is closed, the lamp operates at its stated rating of 60 W.

Calculate the current in the lamp.

Space for working and answer

2

3. (continued)

(*b*) Switch **S1** is opened and switches **S2** and **S3** are closed.

(i) Calculate the combined resistance of both heating elements.

Space for working and answer

2

(ii) Calculate the total power developed in the heating elements when **S2** and **S3** are closed.

Space for working and answer

2

(iii) State and explain which switch or switches would have to be closed to produce the **LOW** heat setting.

....

....

.... 2

[Turn over

4. The diagram shows three household circuits connected to a consumer unit.
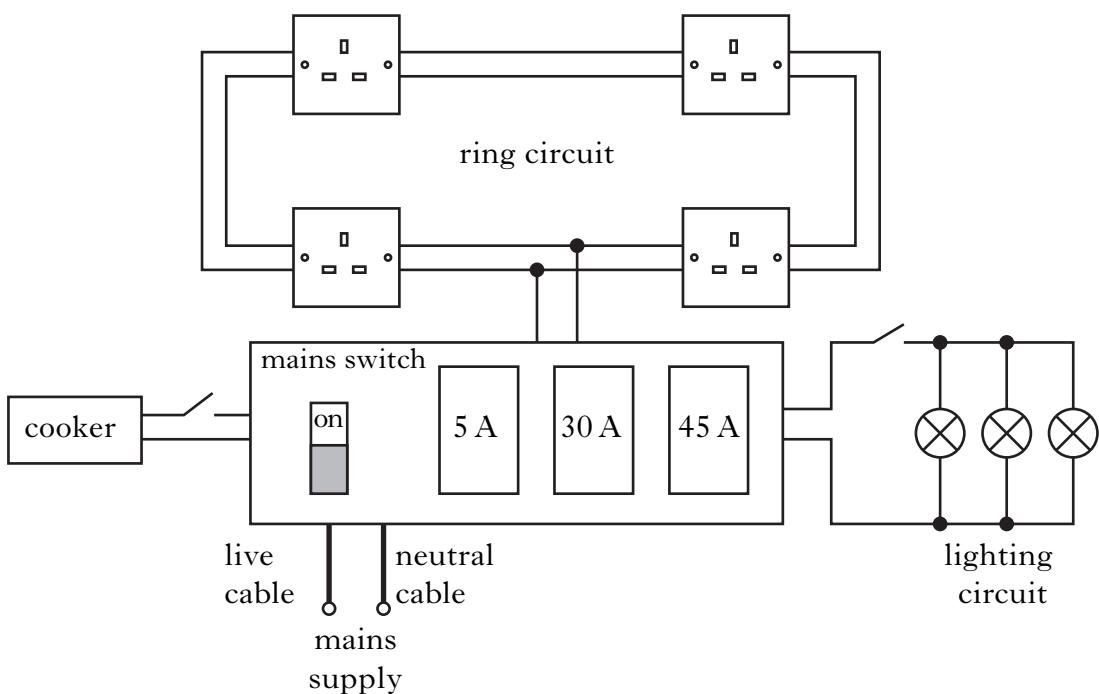
The consumer unit contains a mains switch and three fuses.

The mains supply is also connected to the consumer unit.

The earth wires for these circuits are not shown in the diagram.

(*a*) Explain why the mains switch must be connected to the live cable from the mains supply.

....

.... **1**

(*b*) (i) Complete the table below to show which value of fuse should be connected to each circuit.

Circuit	*Value of fuse*
Lighting Circuit	
Cooker	45 A
Ring Circuit	

1

4. (*b*) (continued)

(ii) The lighting circuit and the ring circuit have different values of fuse.

State another difference between the ring circuit and the lighting circuit.

....   **1**

(*c*) State **one** advantage of using a ring circuit as a preferred method of wiring in parallel.

....

....   **1**

(*d*) Circuit breakers can be used in a consumer unit instead of fuses.

State **one** advantage of using a circuit breaker instead of a fuse.

....

....   **1**

[Turn over

5. A patient visits an ophthalmologist for an eye examination.

The ophthalmologist uses ultrasound to take measurements inside the eye.

retina

ultrasound
transmitter and
receiver
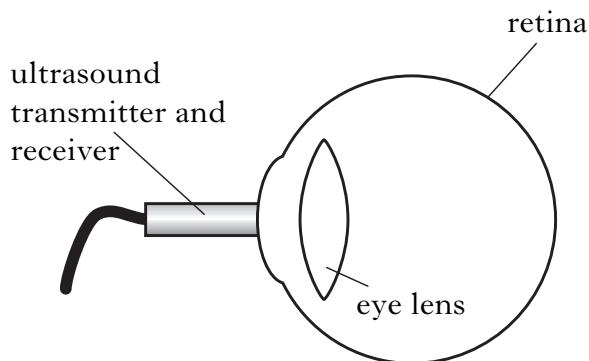
eye lens

(*a*) What name describes the shape of the eye lens?

....   **1**

(*b*) The ophthalmologist has a graph obtained using measurements from a person with normal eyesight.   The graph shows times to receive reflected ultrasound pulses from the **front** edge of the eye lens, the **back** edge of the eye lens and from the **retina**.

*amplitude
of reflected
pulses* in
mV

time for reflected pulses in μs
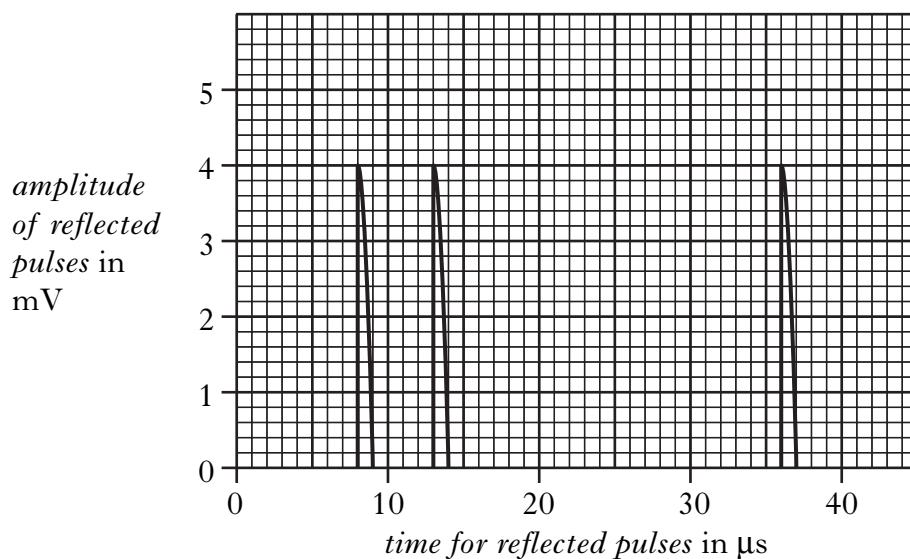
(i) Calculate the time taken for the ultrasound to travel from the **front** edge to the **back** edge of the eye lens.

Space for working and answer

2

Marks

5. **(*b*)** **(continued)**

(ii)   Ultrasound pulses travel at a speed of $1500\,\text{m/s}$ inside the lens.

Calculate the thickness of the lens in the normal-sighted person.

Space for working and answer

2

(*c*)   Another set of measurements indicates that a patient is long-sighted and requires spectacles. Figure 1 shows rays of light from a book entering an eye of this patient until the rays reach the retina.
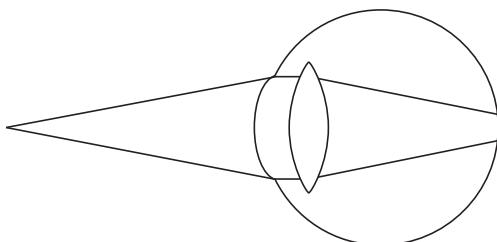

Figure 1

(i)   In the dotted box in Figure 2, draw the shape of lens that would correct this eye defect.
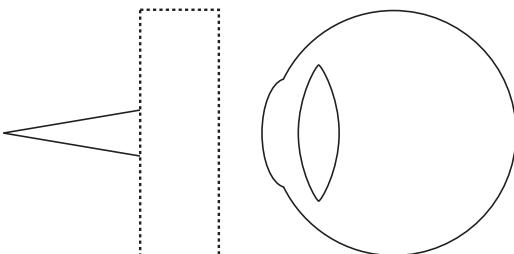
1

Figure 2

(ii)   In Figure 2, complete the path of the rays of light from this lens until they reach the retina.

2

(iii)   One lens used has a power of $1\cdot4\,\text{D}$.

Calculate its focal length.

Space for working and answer

2

**6.** A teacher is demonstrating absorption of alpha, beta and gamma radiations.

(*a*) The teacher explains that when these radiations are absorbed they may cause ionisation in the absorbing material.

(i) Which of the two diagrams below represents an ionised atom?

Explain your answer.
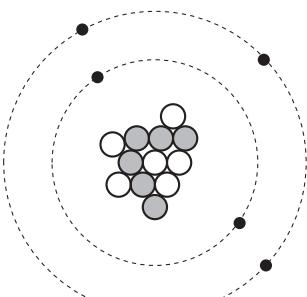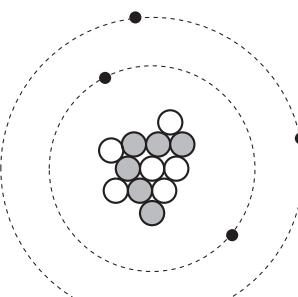
○ proton

◉ neutron

• electron

diagram 1   *diagram 2*

....

.... **2**

(ii) Which type of radiation: alpha, beta or gamma causes most ionisation?

.... **1**

(*b*) The radioactive sources are stored in lead-lined boxes. This is a safety precaution to minimise exposure of students and teacher to radiations from the sources.

State **one** further safety precaution that should be taken by the teacher when handling the radioactive sources.

.... **1**

(*c*) Radioactive materials are used in hospitals.

(i) Describe **one** medical use of radiation where the radiation is used to destroy cells.

.... **1**

6. **(c)** **(continued)**

(ii) A hospital physicist is working with some radioactive materials. The physicist wears a badge containing photographic film. Light cannot reach the film.

aluminium
1 mm thickness

uncovered
window

lead
1 mm thickness
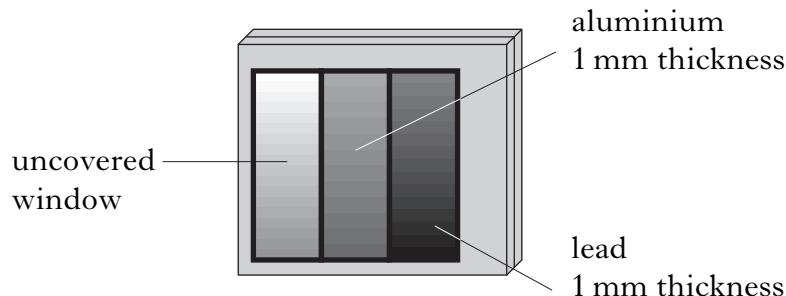
When developed, it is found that the film behind both the uncovered window and the window covered with 1 mm thick aluminium have turned black.

State which type of radiation could cause the film in **only** these areas to turn black.

.... **1**

(iii) It is found that the physicist has received an equivalent dose of 2 mSv due to this radiation.

(A) In the sentence below, circle **one** phrase in the brackets to make the statement correct.

The effect of an equivalent dose of 2 mSv of gamma radiation

is $\left\{\begin{array}{l}\text{the same as}\\ \text{greater than}\\ \text{less than}\end{array}\right\}$ an equivalent dose of 2 mSv of beta

radiation. **1**

(B) Explain your answer.

....

.... **1**

[Turn over

7. An automatic hand dryer used in a washroom is shown in the diagram below.

side view
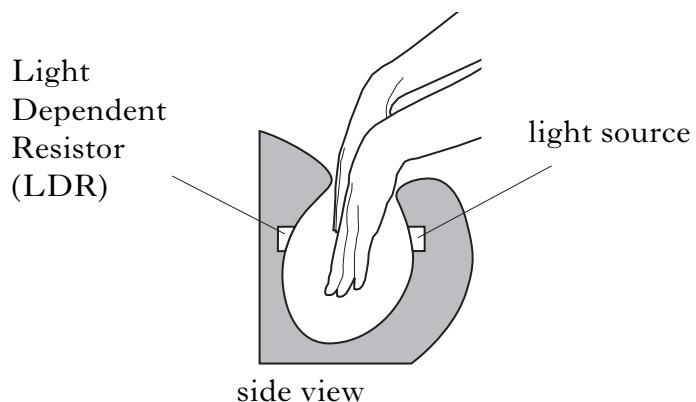
Inserting hands into the dryer breaks a light beam, this is detected using a light dependent resistor (LDR). The LDR is part of a switching circuit which activates the dryer when hands are inserted.

Part of the circuit for the hand dryer is shown.
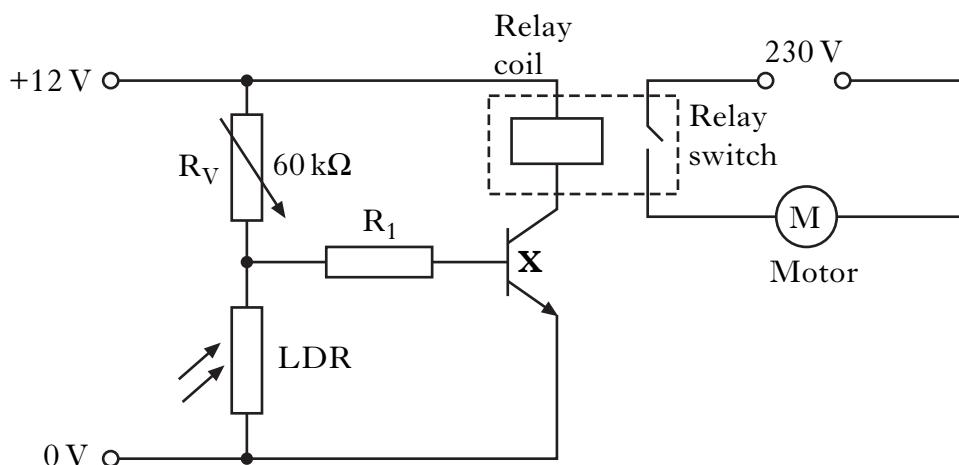
(a) The variable resistor R_V is set to a resistance of $60\,k\Omega$.

Calculate the voltage across the LDR when its resistance is $4\,k\Omega$.

Space for working and answer

2

7. **(continued)**

(*b*) Name component **X** in the circuit diagram.

.... **1**

(*c*) Explain how this circuit operates to activate the motor in the dryer when the light level falls below a certain value.

....

....

....

....

.... **2**

[Turn over

**8.** A house is fitted with a burglar alarm. The outside doors are fitted with magnetic contact switches that detect a door being opened. An infra-red sensor detects movement inside the house. An alarm box produces flashes of light and pulses of sound when activated.

The alarm system can be switched on or off using a master switch.

Alarm box
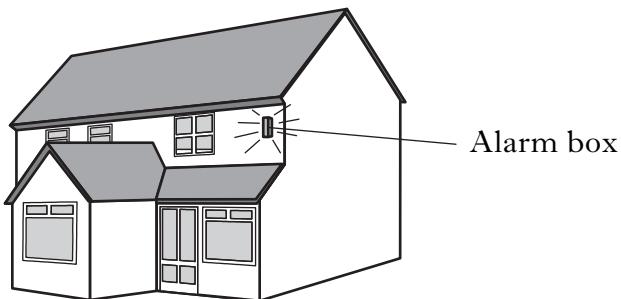
The logic circuit for part of the alarm system is shown below.
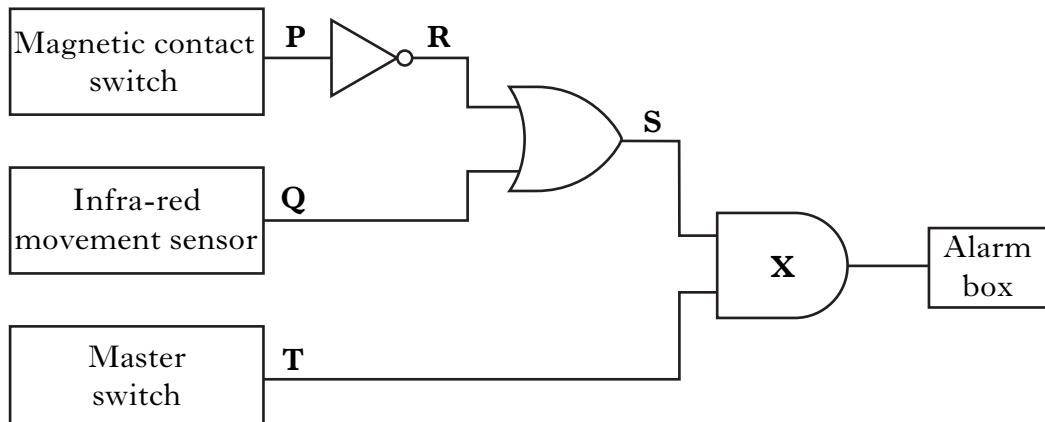
When a door is opened, the logic level at **P** changes from logic **1** to logic **0**.

When the infra-red movement sensor detects movement, the logic level at **Q** changes from logic **0** to logic **1**.

When the master switch is **ON**, the logic level at **T** is logic **1**.

(*a*) Complete the truth table below to show the logic levels at **R** and **S** in the logic circuit.

P	Q	R	S
0	0		
1	0		
0	1		
1	1		

2

8. (continued)

    (*b*) (i) Name the logic gate **X** shown in the logic circuit.

        .... **1**

      (ii) Explain why this type of gate must be connected to the master switch to allow the alarm box to be switched OFF.

        ....

        .... **1**

      (iii) Name a suitable output device that could be used in the alarm box to produce an audio output.

 **1**

[Turn over

9. On a visit to a theme park, four students ride the log flume.

Log is pulled to
top of second drop

Log is pulled to
top of first drop

C

Start

A

water trough

B

D water trough
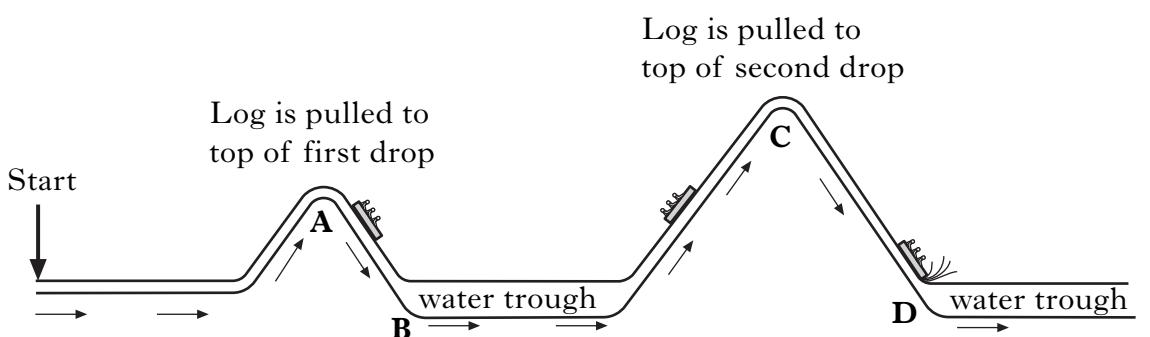
Not to scale

(*a*) The graph shows how the speed of the log varies during the ride.

speed in
m/s
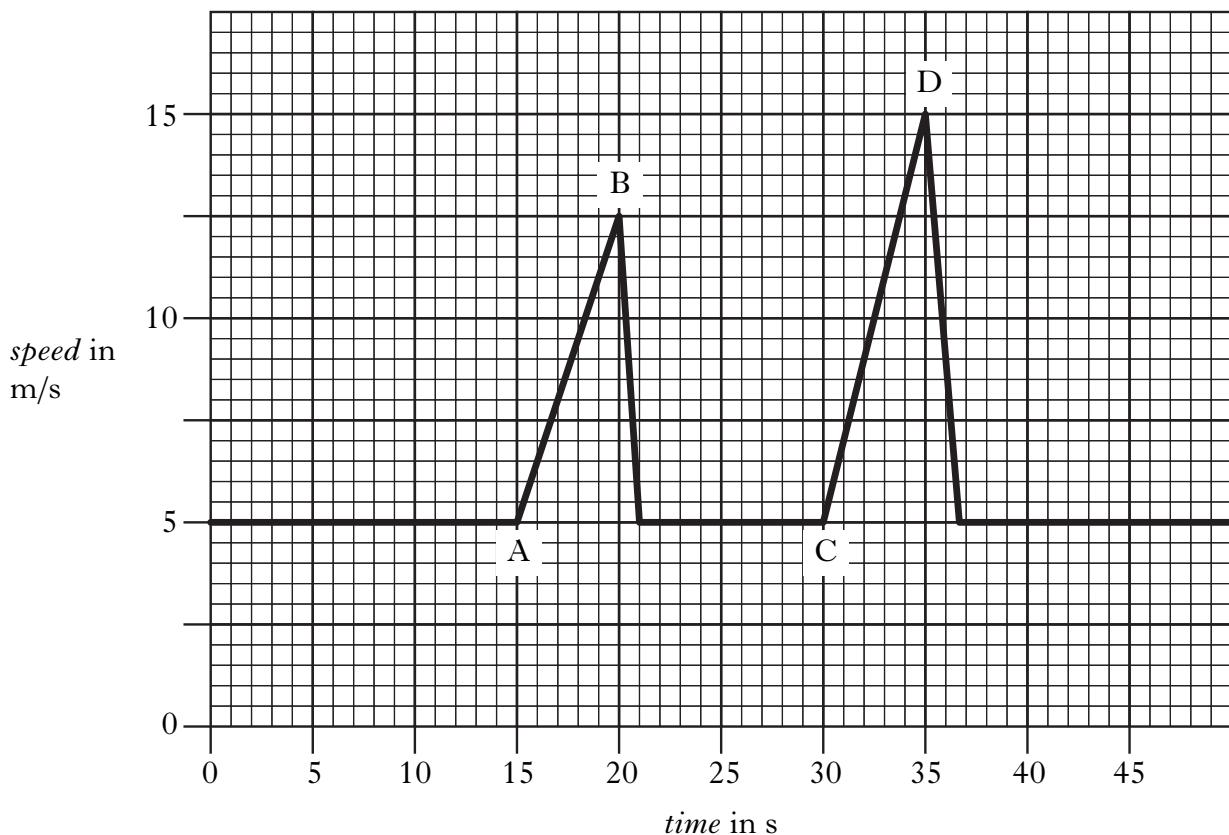
(i) Describe the motion of the log during **AB** on the graph.

.... **1**

9. (*a*) (continued)

(ii) Calculate the distance travelled by the log from the start of the ride to the bottom of the first drop.

Space for working and answer

2

(iii) Calculate the log's acceleration as it goes down the second drop.

Space for working and answer

2

(*b*) Describe how the instantaneous speed of the log could be measured at position **D** on the log flume.

....

....

....

....

.... **3**

[Turn over

10. Two students are playing a game of air hockey. An air hockey table has small holes in its surface through which air is blown. A **mallet** is used to strike the **puck**. The puck moves off on the cushion of air.

puck

mallet

(*a*) The puck has a mass of 35 g.

Calculate the weight of the puck.

Space for working and answer

2

(*b*) The puck is struck by the mallet and moves off with a speed of 4·0 m/s.

(i) State the speed at which the puck hits the side cushion.

.... **1**

(ii) Explain your answer.

....

.... **1**

10. **(continued)**

(*c*) The air supply to the table is switched off. This time the puck leaves the mallet with a speed of 8·0 m/s. A frictional force between the puck and the table causes the puck to stop moving after it has travelled a certain distance.

(i) Calculate the kinetic energy of the puck as it leaves the mallet.

> *Space for working and answer*

2

(ii) The average frictional force acting on the puck is 5·0 N.

Calculate the distance travelled by the puck.

> *Space for working and answer*

3

[Turn over

11. A steam cleaner rated at $2\,kW$ is used to clean a carpet. The water tank is filled with $1\cdot6\,kg$ of water at $20\,°C$. This water is heated until it boils and produces steam. The brush head is pushed across the surface of the carpet and steam is released.
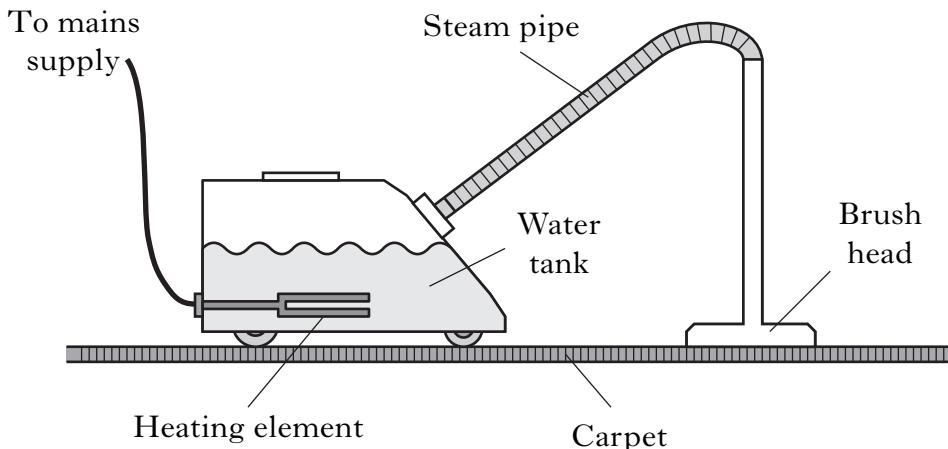
(*a*) Calculate how much heat energy is needed to bring this water to its boiling point of $100\,°C$.

> *Space for working and answer*

3

(*b*) After the steam cleaner has been used for a period of time, $0\cdot9\,kg$ of boiling water has changed into steam.

   (i) Calculate how much heat energy was needed to do this.

> *Space for working and answer*

3

11. (*b*) (continued)

(ii) Calculate how long it would take to change this water into steam.

Space for working and answer

2

[Turn over

12. A small submersible pump is used in a garden water fountain. The pump raises 25 kg of water each minute from a reservoir at ground level.

The water travels through a plastic tube and reaches a height of 1·2 m above ground level.

1·2 m

Plastic tube

Water reservoir

Ground level

Submersible pump
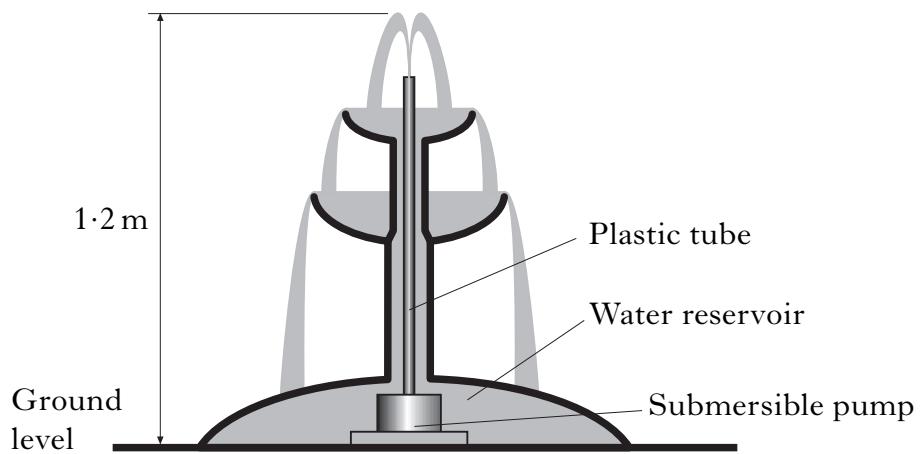
(*a*) Calculate how much gravitational potential energy the water gains each minute.

> *Space for working and answer*

2

(*b*) (i) The pump system is 40% efficient.

Calculate the input power in watts.

> *Space for working and answer*

3

(ii) Give **two** reasons why the pump system is not 100% efficient.

....

.... **2**

DO NOT
WRITE IN
THIS
MARGIN

Marks

K&U   PS

13. A car driver exits a car park having accidentally left a package resting on the roof of the car. The car is travelling at a constant speed of 15 m/s when the driver brakes suddenly and the car stops. The package continues to move forward.
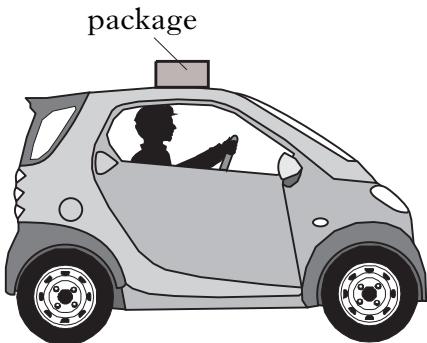
package

(*a*) (i) On the above diagram sketch the path taken by the package. **1**

(ii) Explain why the package follows this path.

....

....

.... **2**

(*b*) The package takes 0·55 s to fall to the ground.

Calculate its vertical speed as it reaches the ground.

Space for working and answer

3

[Turn over

14. All stars emit electromagnetic radiation. The diagram below shows the electromagnetic spectrum in order of increasing wavelength. The names of **three** of the radiations are missing.

Gamma rays	X-rays	**P**	Visible light	**Q**	**R**	TV and Radio

⟶

Increasing wavelength

(*a*) (i) Name radiation:

P ....

Q ....

R **2**

(ii) Which radiation in the electromagnetic spectrum has the lowest frequency?

.... **1**

14. (continued)

(*b*) Some spectral lines of radiation from a distant star are shown below.

Spectral lines of radiation from distant star

The spectral lines of a number of elements are also shown.

Cadmium
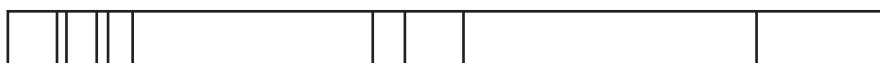
Calcium

Krypton
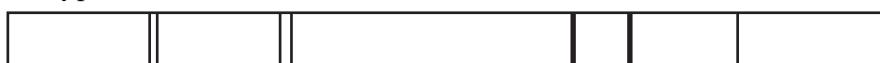
Mercury
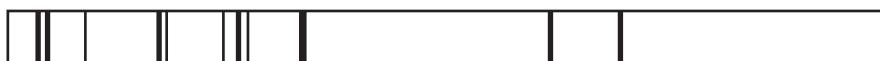
Use the spectral lines of the elements shown above to identify which of these elements are present in the distant star.

.... **2**

[Turn over for Question 15 on *Page thirty*

15. The first manned space flights took place 50 years ago. Spacecraft were launched into space using powerful rockets.
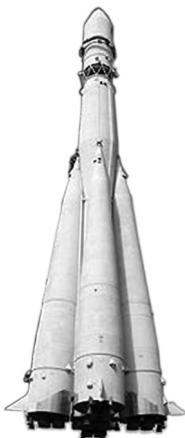
(*a*) The operation of a rocket engine can be explained using Newton's Third Law of Motion.

   (i) State Newton's Third Law of Motion.

   ....

   .... **1**

   (ii) Explain, in terms of Newton's Third Law, how the rocket engines propel the rocket upwards.

   ....

   .... **1**

(*b*) At lift-off, one rocket has a total mass of $2{\cdot}05 \times 10^6$ kg. The resultant force acting upwards on the rocket is $8{\cdot}2 \times 10^6$ N.

Calculate the acceleration of the rocket at lift-off.

Space for working and answer

2

[*END OF QUESTION PAPER*]

ADDITIONAL SPACE FOR ANSWERS

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

ADDITIONAL SPACE FOR ANSWERS

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