National 5 Physics Past Papers

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1 Intro

This document was created in order to make it easier to find past paper questions both for teachers and students. I will do my best to keep this document up to date and include new past paper questions as they become available. If you spot any mistakes, or want to suggest any improvements, send me an email at MrDaviePhysics@gmail.com. I am more than happy to send you the Tex file used to produce the document so that you can modify it as you wish.

2 How to Use

The table on the next page contains links to questions sorted by topic and year. Clicking on a link will take you to that question. The marking instructions follow directly after each question with the exception of multiple choice questions and open ended questions. The answers to multiple choice are at the end of that section of multiple choice questions. I have not included the marking instructions for open ended questions as they do not contain enough information for you to mark your own work. Instead ask your teacher to have a look at what you have written. To return to the table click on **Back to Table** at the top or bottom of any page. Trying to navigate the document without doing this is difficult.

Before starting any past paper questions I recommend that you have paper copies of the Relationships Sheet and Data Sheet.

	2014		2015		2016		2017		SPQ		2018		2019	
	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2
Vectors and Scalars	14,15	11c	14	7	14	9	14	8a,c	1,2	b	1,2	1a(i),2	1	1
v-t graphs and Acceleration		10	15	8	15	10a,b	15,16	8b		1a,c		2a(iii), b,c	2,3	2a(i),2b
Newton's Laws	17	10a(iii) 11a,b 12a,c-e	17,18	7b,10c	17	12a,c	17	9	3,4,7	2a	3	1a		1d, 2a(ii), 2a(iii)
Energy	4,16		16	11a	16		1		5,6	2c(ii)	4	3a,b		9c
Projectile motion	19			9	18			11a,b				3c	4, 6	
Space exploration and Cosmology	18		19,20		20	13c,d	18,20	12	7,8	2,3	5,6,7, 8,9,10	4	7	4
Electrical Charge Carriers					2	1	2	1b	9,10		11,12	6c	8	
Voltage, Ohm's Law & Circuit rules	1,2,3	1b, 2	1,2,3	1	1,3,4	2,3c, 12b	3,4	2a(i) 2b(i)	11,12, 14	5a,6	13,14	6a,b	9,10, 11,12	6
Electrical Power & Energy		1a	4	2		3b		1a,2, 11c		5b	4,15	8b		6a(ii),b(ii)
Specific heat Capacity & Specific latent heat	20	3			19	3a	5,19		13,15	7	16	8a,c	13	7
Gas laws & the kinetic model	5,6,7	12b	5,6	5d	5,6,7	13b	6,7	3	16,17	8	17, 18,19	1b,9	15,16	8
Wave parameters & behaviours	8	4a	7	3	8,9, 10		8 ,9,10	4	18,19	9	20	10,11b	17,18, 19	9a,b
Electromagnetic spectrum	9		8			4	11	b(i)	20		21	11a		10
Refraction of light		4b		5a-c	11	6	12		21			11c	20	11
Nuclear radiation	10,11, 12,13	6,8	9,10, 11,12, 13	6	12,13	7, 8, 13a	13	6,7	22,23, 24,25	11,12	23,24, 25	12,13	21,22, 23,24, 25	12,13
Open ended		7,9		4 , 10		5, 11		5,10		4,10		5,7		3,13
Unseen formula/PS		5								2d	22		5,14	
Experimental Methods				11b,c										5

	2020		2022		2023		2024		2025		2026		2027	
	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2
Vectors and Scalars	1	1a,c	1	1,5a(iii)										
v-t graphs and Acceleration		1b,2a	2,3											
Newton's Laws	2,3	2b	4											
Energy		2c,3b,c,4d(i)	5											
Projectile motion	5	6												
Space exploration and Cosmology	6,7,8,9	4,5	7,8,9,10	3,4,5										
Electrical Charge Carriers	10,11		11											
Voltage, Ohm's Law & Circuits	12,13	6,7a,7b(i),8b(i)	12,13,14	6,7c										
Electrical Power & Energy		3b(i),7b(ii,iii), 8b(ii)		7a,b,8a,11b,14b(i)										
Specific heat Capacity & Specific latent heat	14,15	8a,c	15,16	8b										
Gas laws & the kinetic model	16,17,18	9	17	9										
Wave parameters & behaviours	19	1a,4e,11	19,20	10										
Electromagnetic spectrum			21											
Refraction of light	20,21			11a										
Nuclear radiation	22,23, 24,25	12,13	22,23, 24,25	13,14										
Open ended		5,10		4,12b										
Unseen formula/PS	4		18											
Experimental Methods				2,12a										

N5 National Qualifications 2014

X757/75/02

Physics
Section 1—Questions

THURSDAY, 22 MAY

9:00 AM – 11:00 AM

Instructions for the completion of Section 1 are given on Page two of your question and answer booklet X757/75/01.

Record your answers on the answer grid on Page three of your question and answer booklet.

Reference may be made to the Data Sheet on Page two of this booklet and to the Relationship Sheet X757/75/11.

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

DATA SHEET

Speed of light in materials

Material	*Speed* in m s^{-1}
Air	$3·0 \times 10^8$
Carbon dioxide	$3·0 \times 10^8$
Diamond	$1·2 \times 10^8$
Glass	$2·0 \times 10^8$
Glycerol	$2·1 \times 10^8$
Water	$2·3 \times 10^8$

Gravitational field strengths

	Gravitational field strength on the surface in N kg^{-1}
Earth	9·8
Jupiter	23
Mars	3·7
Mercury	3·7
Moon	1·6
Neptune	11
Saturn	9·0
Sun	270
Uranus	8·7
Venus	8·9

Specific latent heat of fusion of materials

Material	*Specific latent heat of fusion* in J kg^{-1}
Alcohol	$0·99 \times 10^5$
Aluminium	$3·95 \times 10^5$
Carbon Dioxide	$1·80 \times 10^5$
Copper	$2·05 \times 10^5$
Iron	$2·67 \times 10^5$
Lead	$0·25 \times 10^5$
Water	$3·34 \times 10^5$

Specific latent heat of vaporisation of materials

Material	*Specific latent heat of vaporisation* in J kg^{-1}
Alcohol	$11·2 \times 10^5$
Carbon Dioxide	$3·77 \times 10^5$
Glycerol	$8·30 \times 10^5$
Turpentine	$2·90 \times 10^5$
Water	$22·6 \times 10^5$

Speed of sound in materials

Material	*Speed* in m s^{-1}
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Specific heat capacity of materials

Material	*Specific heat capacity* in J kg^{-1} °C^{-1}
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Ice	2100
Iron	480
Lead	128
Oil	2130
Water	4180

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
Iron	1537	2737

Radiation weighting factors

Type of radiation	*Radiation weighting factor*
alpha	20
beta	1
fast neutrons	10
gamma	1
slow neutrons	3
X-rays	1

Back to Table

SECTION 1

1. The voltage of an electrical supply is a measure of the

A resistance of the circuit

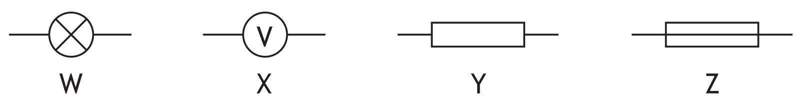
B speed of the charges in the circuit

C power developed in the circuit

D energy given to the charges in the circuit

E current in the circuit.

2. Four circuit symbols, W, X, Y and Z, are shown.



Which row identifies the components represented by these symbols?

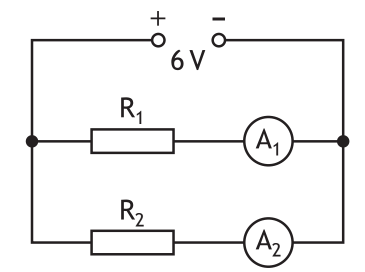
	W	*X*	*Y*	*Z*
A	battery	ammeter	resistor	variable resistor
B	battery	ammeter	fuse	resistor
C	lamp	ammeter	variable resistor	resistor
D	lamp	voltmeter	resistor	fuse
E	lamp	voltmeter	variable resistor	fuse

[Turn over

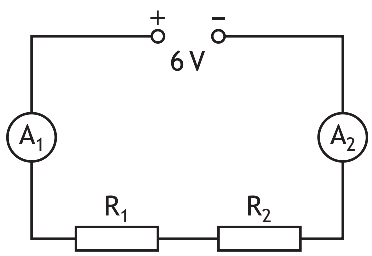
3. A student suspects that ammeter A_1 may be inaccurate. Ammeter A_2 is known to be accurate.

Which of the following circuits should be used to compare the reading on A_1 with A_2?

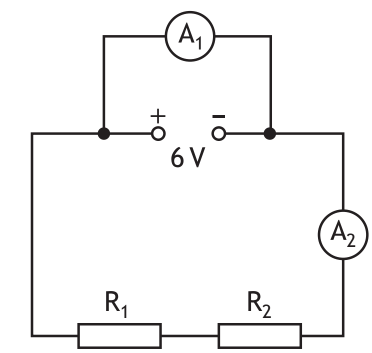
A



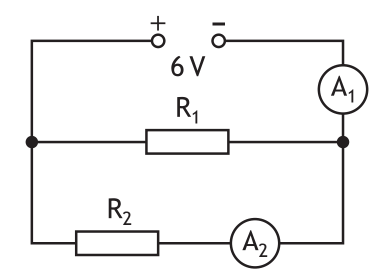
B



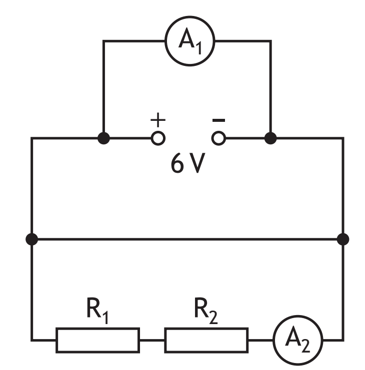
C



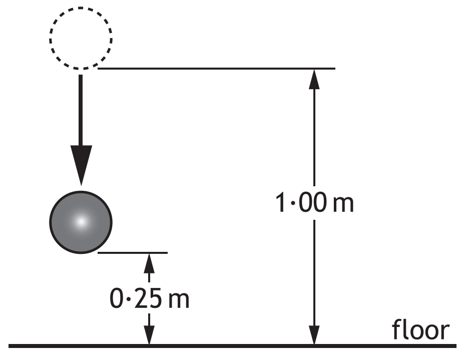
D



E



4. A ball of mass 0·50 kg is released from a height of 1·00 m and falls towards the floor.



Which row in the table shows the gravitational potential energy and the kinetic energy of the ball when it is at a height of 0·25 m from the floor?

	Gravitational potential energy (J)	*Kinetic energy* (J)
A	0·12	0·12
B	1·2	1·2
C	1·2	3·7
D	3·7	1·2
E	4·9	1·2

5. The pressure of a fixed mass of gas is $6{\cdot}0 \times 10^5$ Pa.

The temperature of the gas is 27 ºC and the volume of the gas is $2{\cdot}5\,m^3$.

The temperature of the gas increases to 54 ºC and the volume of the gas increases to $5{\cdot}0\,m^3$.

What is the new pressure of the gas?

A $2{\cdot}8 \times 10^5$ Pa

B $3{\cdot}3 \times 10^5$ Pa

C $6{\cdot}0 \times 10^5$ Pa

D $1{\cdot}1 \times 10^6$ Pa

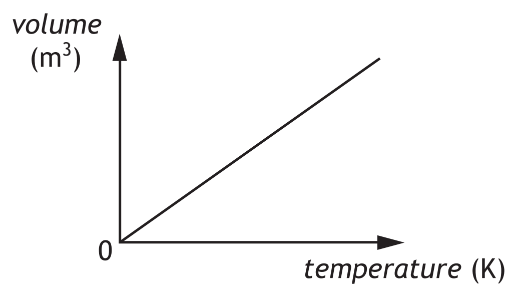
E $1{\cdot}3 \times 10^6$ Pa

[Turn over

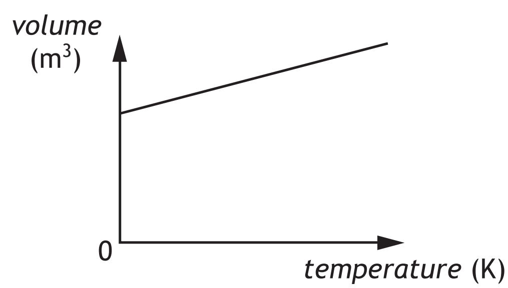
6. A student is investigating the relationship between the volume and the kelvin temperature of a fixed mass of gas at constant pressure.

Which graph shows this relationship?

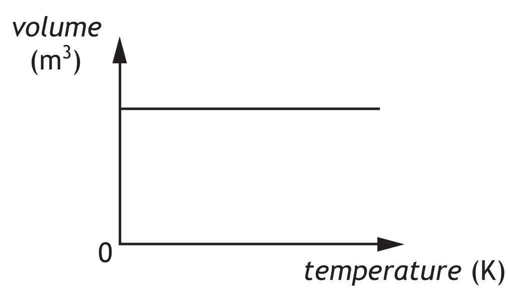
A



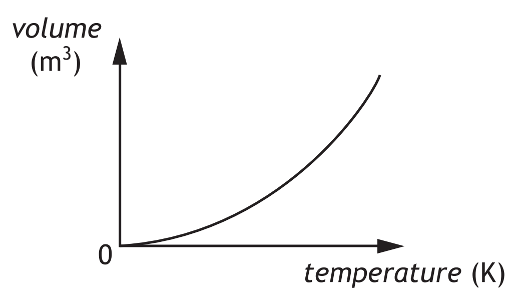
B



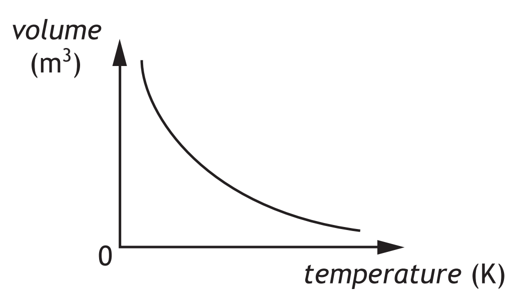
C



D



E



7. A liquid is heated from 17 °C to 50 °C. The temperature rise in kelvin is

A 33 K
B 67 K
C 306 K
D 340 K
E 579 K.

8. The period of vibration of a guitar string is 8 ms.
The frequency of the sound produced by the guitar string is

A 0·125 Hz
B 12·5 Hz
C 125 Hz
D 800 Hz
E 8000 Hz.

9. A student makes the following statements about microwaves and radio waves.

I In air, microwaves travel faster than radio waves.
II In air, microwaves have a longer wavelength than radio waves.
III Microwaves and radio waves are both members of the electromagnetic spectrum.

Which of these statements is/are correct?

A I only
B III only
C I and II only
D I and III only
E II and III only

10. Which row describes alpha (α), beta (β) and gamma (γ) radiations?

	α	β	γ
A	helium nucleus	electromagnetic radiation	electron from the nucleus
B	helium nucleus	electron from the nucleus	electromagnetic radiation
C	electron from the nucleus	helium nucleus	electromagnetic radiation
D	electromagnetic radiation	helium nucleus	electron from the nucleus
E	electromagnetic radiation	electron from the nucleus	helium nucleus

[Turn over

11. A sample of tissue is irradiated using a radioactive source.

A student makes the following statements about the sample.

I The equivalent dose received by the sample is reduced by shielding the sample with a lead screen.

II The equivalent dose received by the sample is increased as the distance from the source to the sample is increased.

III The equivalent dose received by the sample is increased by increasing the time of exposure of the sample to the radiation.

Which of these statements is/are correct?

A I only

B II only

C I and II only

D II and III only

E I and III only

12. The half-life of a radioactive source is 64 years.

In 2 hours, $1 \cdot 44 \times 10^8$ radioactive nuclei in the source decay.

What is the activity of the source in Bq?

A 2×10^4

B 4×10^4

C $1 \cdot 2 \times 10^6$

D $2 \cdot 25 \times 10^6$

E $7 \cdot 2 \times 10^7$

13. A student makes the following statements about the fission process in a nuclear power station.

I Electrons are used to bombard a uranium nucleus.

II Heat is produced.

III The neutrons released can cause other nuclei to undergo fission.

Which of these statements is/are correct?

A I only

B II only

C III only

D I and II only

E II and III only

14. Which of the following contains two vectors and one scalar quantity?

A Acceleration, mass, displacement

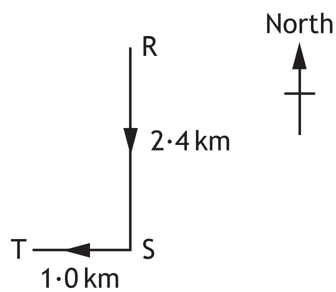
B Displacement, force, velocity

C Time, distance, force

D Displacement, velocity, acceleration

E Speed, velocity, distance

15. A vehicle follows a course from R to T as shown.



The total journey takes 1 hour.

Which row in the table gives the average speed and the average velocity of the vehicle for the whole journey?

	Average speed	*Average velocity*
A	$2{\cdot}6\,\text{km h}^{-1}$ (023)	$3{\cdot}4\,\text{km h}^{-1}$
B	$2{\cdot}6\,\text{km h}^{-1}$	$3{\cdot}4\,\text{km h}^{-1}$ (203)
C	$3{\cdot}4\,\text{km h}^{-1}$ (203)	$2{\cdot}6\,\text{km h}^{-1}$
D	$3{\cdot}4\,\text{km h}^{-1}$	$2{\cdot}6\,\text{km h}^{-1}$ (023)
E	$3{\cdot}4\,\text{km h}^{-1}$	$2{\cdot}6\,\text{km h}^{-1}$ (203)

16. A force of 10 N acts on an object for 2 s.

During this time the object moves a distance of 3 m.

The work done on the object is

A 6·7 J

B 15 J

C 20 J

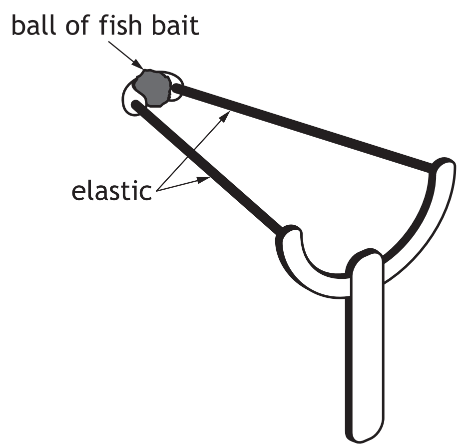
D 30 J

E 60 J.

[Turn over

17. Catapults are used by anglers to project fish bait into water.

A technician designs a catapult for this use.



Pieces of elastic of different thickness are used to provide a force on the ball.

Each piece of elastic is the same length.

The amount of stretch given to each elastic is the same each time.

The force exerted on the ball increases as the thickness of the elastic increases.

Which row in the table shows the combination of the thickness of elastic and mass of ball that produces the greatest acceleration?

	Thickness of elastic (mm)	*Mass of ball* (kg)
A	5	0·01
B	10	0·01
C	10	0·02
D	15	0·01
E	15	0·02

18. A spacecraft completes the last stage of its journey back to Earth by parachute, falling with constant speed into the sea.

The spacecraft falls with constant speed because

A the gravitational field strength of the Earth is constant near the Earth's surface

B it has come from space where the gravitational field strength is almost zero

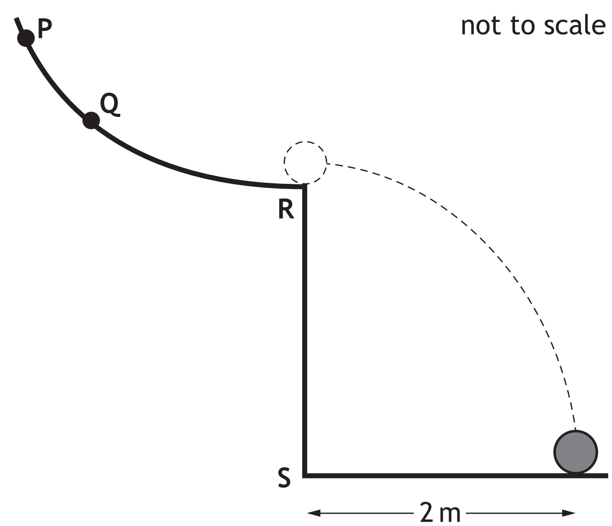
C the air resistance is greater than the weight of the spacecraft

D the weight of the spacecraft is greater than the air resistance

E the air resistance is equal to the weight of the spacecraft.

19. A ball is released from point **Q** on a curved rail, leaves the rail horizontally at R and lands 1 s later.

The ball is now released from point **P**.



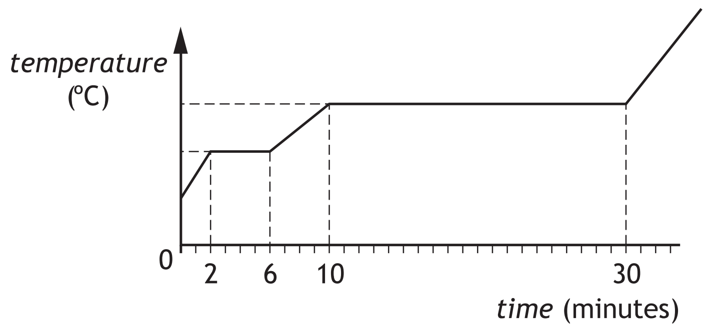
Which row describes the motion of the ball after leaving the rail?

	Time to land after leaving rail	*Distance from S to landing point*
A	1 s	less than 2 m
B	less than 1 s	more than 2 m
C	1 s	more than 2 m
D	less than 1 s	2 m
E	more than 1 s	more than 2 m

[Turn over

20. A solid substance is placed in an insulated flask and heated continuously with an immersion heater.

The graph shows how the temperature of the substance in the flask changes in time.



After 5 minutes the substance is a

A solid

B liquid

C gas

D mixture of solid and liquid

E mixture of liquid and gas.

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET]

Detailed Marking Instructions for each question

Section 1

Question	Answer	Max Mark
1.	D	**1**
2.	D	**1**
3.	B	**1**
4.	C	**1**
5.	B	**1**
6.	A	**1**
7.	A	**1**
8.	C	**1**
9.	B	**1**
10.	B	**1**
11.	E	**1**
12.	A	**1**
13.	E	**1**
14.	A	**1**
15.	E	**1**
16.	D	**1**
17.	D	**1**
18.	E	**1**
19.	C	**1**
20.	D	**1**

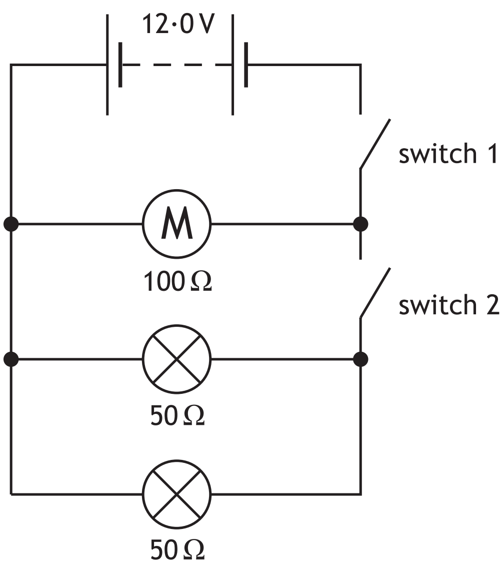
SECTION 2 — 90 marks

Attempt ALL questions

MARKS | DO NOT WRITE IN THIS MARGIN

1. A toy car contains an electric circuit which consists of a 12·0 V battery, an electric motor and two lamps.

The circuit diagram is shown.



(a) Switch 1 is now closed.

Calculate the power dissipated in the motor when operating. **3**

Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

1. (continued)

(b) Switch 2 is now also closed.

(i) Calculate the total resistance of the motor and the two lamps. **3**

Space for working and answer

(ii) One of the lamps now develops a fault and stops working.

State the effect this has on the other lamp.

You **must** justify your answer. **2**

Total marks 8

[Turn over

Section 2

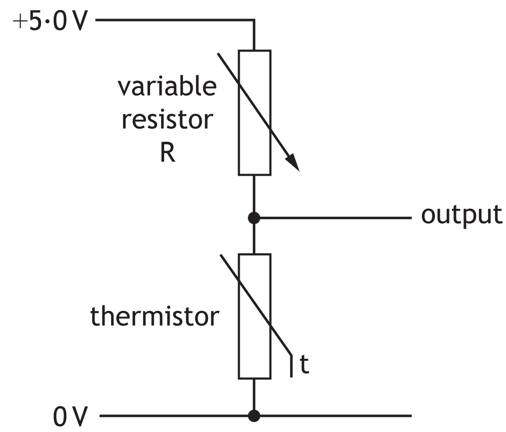
Question			Answer		Max Mark	Additional Guidance
1.	(a)		$P=\dfrac{V^2}{R}$	(1)	**3**	Accept 1, 1·4, 1·44 Do not accept: 1·40 Alternative methods: $I=\dfrac{V}{R}$ $=\dfrac{12\cdot0}{100}$ $=0\cdot12$ (A) $P=IV$ $=0\cdot12\times12$ $=1\cdot44$ W OR $P=I^2R$ $=0\cdot12^2\times100$ $=1\cdot44$ W (1) mark for both formulae (1) mark for both substitutions (1) mark for final answer and unit
			$=\dfrac{12\cdot0^2}{100}$	(1)		
			$=1\cdot44$ W	(1)		

Question			Answer	Max Mark	Additional Guidance
	(b)	(i)	$\frac{1}{R_T}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$ (1) $\frac{1}{R_T}=\frac{1}{100}+\frac{1}{50}+\frac{1}{50}$ (1) $\frac{1}{R_T}=\frac{1}{20}$ $R_T=20\Omega$ (1)	**3**	If wrong equation used eg $R_T=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$ then zero marks Accept *imprecise* working towards a final answer $\frac{1}{R_T}=\frac{1}{100}+\frac{1}{50}+\frac{1}{50}= 20\ \Omega$ accept Can be answered by applying product over sum method twice. Accept: $\frac{1}{R_T}=\frac{1}{100}+\frac{1}{25}$

Question			Answer	Max Mark	Additional Guidance
		(ii)	**Effect:** The other lamp: • remains lit • stays on • is the same brightness • gets brighter • is not affected (1) **Justification:** The current still has a path through the other lamp. (1) OR The current in the other lamp is the same (only acceptable if other lamp stays same brightness) (1) OR The current in the other lamp is greater (only acceptable if other lamp gets brighter) (1) OR It has the same voltage / 12 V (across it) (1) OR The lamps are connected in parallel (1)	**2**	First mark can only be awarded if a justification is attempted Effect correct + entire justification correct (2) Effect correct + justification incorrect (1) Effect correct + no justification (0) Incorrect effect regardless of justification (0) If the effect is not stated (0) regardless of justification Do not accept: Other lamp gets dimmer

MARKS | DO NOT WRITE IN THIS MARGIN

2. A thermistor is used as a temperature sensor in a circuit to monitor and control the temperature of water in a tank. Part of the circuit is shown.



(a) (i) The variable resistor R is set at a resistance of 1050 Ω.

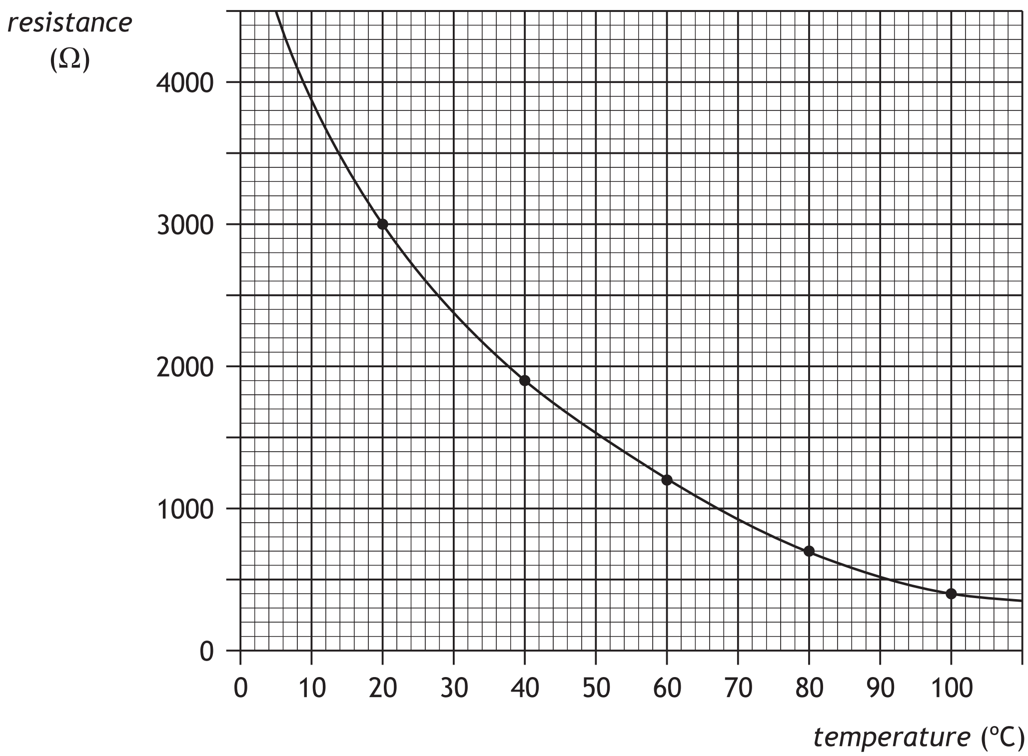
Calculate the resistance of the thermistor when the voltage across the thermistor is 2·0 V. **4**

Space for working and answer

MARKS DO NOT WRITE IN THIS MARGIN

2. (a) (continued)

(ii) The graph shows how the resistance of the thermistor varies with temperature.

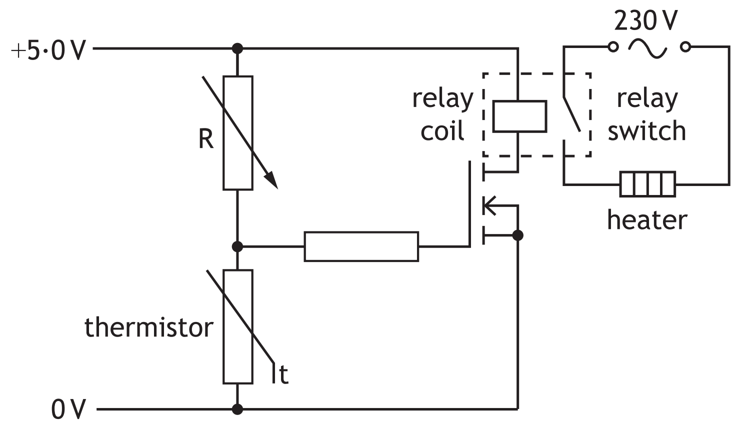


Use the graph to determine the temperature of the water when the voltage across the thermistor is 2·0 V. **1**

MARKS DO NOT WRITE IN THIS MARGIN

2. (continued)

(b) The circuit is now connected to a switching circuit to operate a heater.



(i) Explain how the circuit operates to switch on the heater when the temperature falls below a certain value. **3**

(ii) The resistance of the variable resistor R is now increased.

What effect does this have on the temperature at which the heater is switched on?

You **must** justify your answer. **3**

Total marks 11

Question			Answer	Max Mark	Additional Guidance
2.	(a)	(i)	$V_2 = V_S - V_1 = 3\cdot 0$ (V) $I = \frac{V_2}{R}$ $= \frac{3\cdot 0}{1050}$ $= (2\cdot 857 \times 10^{-3}\ \text{A})$ $R_1 = \frac{V_1}{I}$ $= \frac{2\cdot 0}{2\cdot 857 \times 10^{-3}}$ $= 700\ \Omega$	**4**	(1) mark for 3·0 (V) If no attempt at subtraction is seen then MAX (1) mark for equation If subtraction is incorrect treat as arithmetic error. (1) mark for Ohm's Law (even if only seen once) (1) mark for both substitutions (1) mark for final answer including units Allow correct intermediate rounding of the current but check calculation of final answer s.f. range: 1-4 Alternative methods: 1 mark for 3·0 V (1) If no attempt at subtraction is seen then MAX (1) mark for equation If subtraction is incorrect treat as arithmetic error. $R_1/R_2 = V_1/V_2$ (1) $R_1/1050 = 2\cdot 0/3\cdot 0$ (1) $R_1 = 700\ \Omega$ (1) OR $V_2 = \left(\frac{R_{th}}{R_V + R_{th}}\right) \times V_S$ (1) $2\cdot 0 = \left(\frac{R_{th}}{1050 + R_{th}}\right) \times 5\cdot 0$ (2) $R_{th} = 700\ \Omega$ (1)

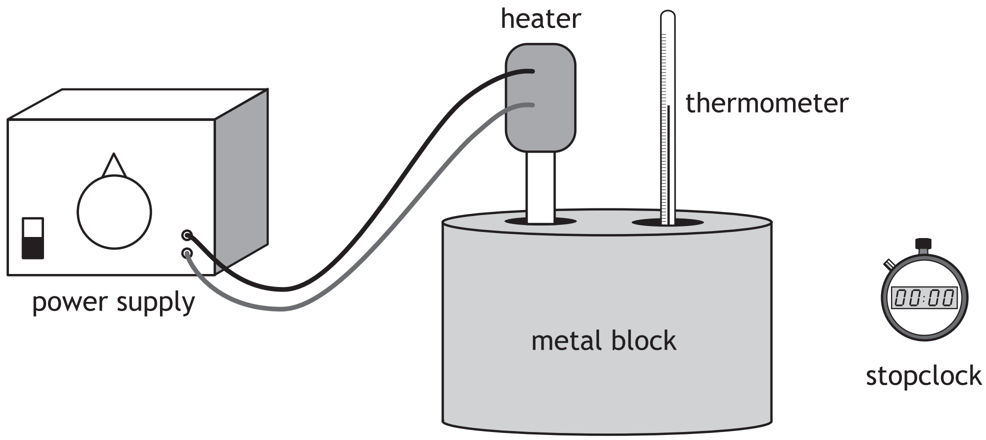
Question			Answer	Max Mark	Additional Guidance
		(ii)	80 °C	**1**	Or answer consistent with 2(a)(i) Unit required +/- half box tolerance
	(b)	(i)	(As R_{th} increases,) V_{th} increases (1) (When V_{th} = 2·0 V or V reaches switching voltage,) MOSFET/transistor turns **on** (1) Relay switches **on** (the heater). (1)	**3**	(3) independent marks Look for: • voltage across thermistor increases • MOSFET/transistor switches **on** / activates • Relay switches **on** / activates / switch closes
		(ii)	Temperature decreases (1) Resistance of **thermistor** must be greater / increase (1) to switch **on** MOSFET / transistor (1)	**3**	First mark can only be awarded if a justification is attempted Effect correct + justification correct (3) Effect correct + justification partially correct (2) Effect correct + justification incorrect (1) Effect correct + no justification (0) Incorrect or no effect stated regardless of justification (0)

MARKS DO NOT WRITE IN THIS MARGIN

3. A student is investigating the specific heat capacity of three metal blocks X, Y and Z.

Each block has a mass of 1·0 kg.

A heater and thermometer are inserted into a block as shown.



The heater has a power rating of 15 W.

The initial temperature of the block is measured.

The heater is switched on for 10 minutes and the final temperature of the block is recorded.

This procedure is repeated for the other two blocks.

The student's results are shown in the table.

Block	*Initial temperature* (°C)	*Final temperature* (°C)
X	15	25
Y	15	85
Z	15	34

(a) Show that the energy provided by the heater to each block is 9000 J. **2**

Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

3. (continued)

(b) (i) By referring to the results in the table, identify the block that has the greatest specific heat capacity. **1**

(ii) Calculate the specific heat capacity of the block identified in (b)(i). **3**

Space for working and answer

(c) Due to energy losses, the specific heat capacities calculated in this investigation are different from the accepted values.

The student decides to improve the set up in order to obtain a value closer to the accepted value for each block.

(i) Suggest a possible improvement that would reduce energy losses. **1**

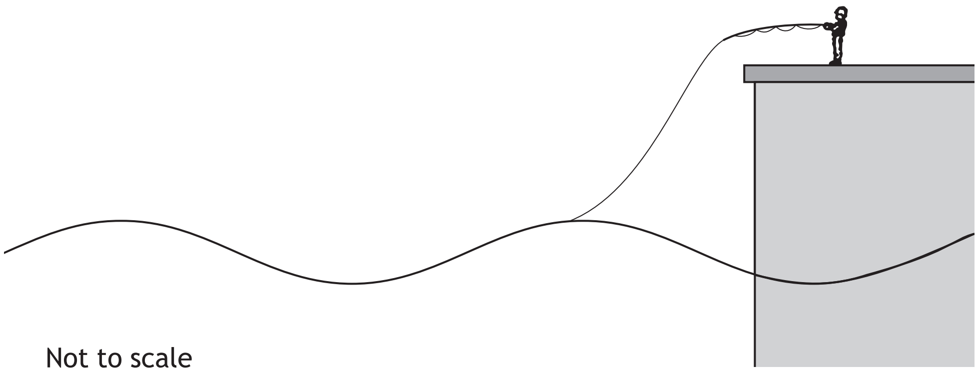
(ii) State the effect that this improvement would have on the final temperature. **1**

Total marks 8

Question			Answer	Max Mark	Additional Guidance
3.	(a)		Must start with the correct formula or (0) marks $E = Pt$ (1) $E = 15 \times 10 \times 60$ (1) $E = 9000$ J	**2**	Final answer of 9000 J must be shown otherwise a maximum of (1) mark can be awarded. Alternative method: $E = Pt$ (1) $9000 = P \times 10 \times 60$ (1) $P = 15$ W This is the same as the power of the heater used. For the alternative method, if the final statement is not included a maximum of (1) mark can be awarded.
	(b)	(i)	X (1)	**1**	
		(ii)	$E = cm\Delta T$ (1) $9000 = c \times 1{\cdot}0 \times 10$ (1) $c = 900$ J kg^{-1} °C^{-1} (1)	**3**	Or consistent with material selected in (b)(i) sig fig range: 1-3 only For block Y: $c = 129$ J kg^{-1} °C^{-1} For block Z: $c = 474$ J kg^{-1} °C^{-1}
	(c)	(i)	Insulating the (metal) block OR Switch heater on for shorter time	**1**	Accept any suitable suggestion
		(ii)	Increase / greater (for insulating) OR Decrease / lower (for shorter time)	**1**	Answer **must** be consistent with (c)(i) If candidate has not made a suitable suggestion in (c)(i) they cannot access the mark in (c)(ii) i.e. if (0) marks awarded for (c)(i) then award (0) marks for (c)(ii).

MARKS | DO NOT WRITE IN THIS MARGIN

4. A student, fishing from a pier, counts four waves passing the end of the pier in 20 seconds. The student estimates that the wavelength of the waves is 12 m.



Not to scale

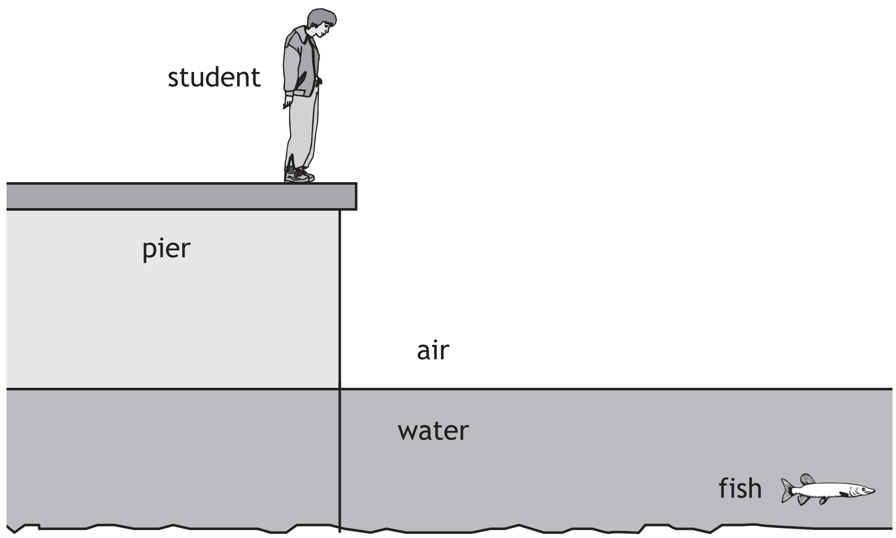
(a) Calculate the speed of the water waves. **4**

Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

4. (continued)

(b) When looking down into the calm water behind the pier the student sees a fish.



Complete the diagram to show the path of a ray of light from the fish to the student.

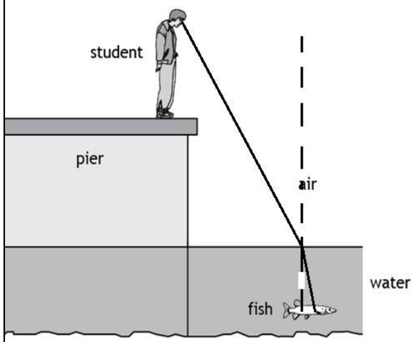
You should include the normal in your diagram. **3**

(An additional diagram, if required, can be found on *Page thirty-one*.)

Total marks 7

[Turn over

Question			Answer	Max Mark	Additional Guidance
4.	(a)		$f =$ N° of waves/time $= \frac{4}{20}$ $= 0{\cdot}2$(Hz) (1) $v = f\lambda$ (1) $= 0{\cdot}2 \times 12$ (1) $= 2{\cdot}4$ m s^{-1} (1)	4	Alternative methods: $d = 12 \times 4 = 48$ (m) (1) $v = \frac{d}{t}$ (1) $= \frac{48}{20}$ (1) $= 2{\cdot}4$ m s^{-1} (1) OR time for 1 wave $= \frac{20}{4}$ $= 5$ (s) (1) $v = \frac{d}{t}$ (1) $= \frac{12}{5}$ (1) $= 2{\cdot}4$ m s^{-1} (1) If arithmetic error in calculation of frequency, distance or time for one wave, then MAX (3) marks. If no attempt made at calculation of frequency, distance or time for one wave, then MAX (1) mark for equation.

Question			Answer	Max Mark	Additional Guidance
	(b)		 (1) mark for ray changing direction at water/air boundary (1) mark for angle in water less than angle in air. Angle of incidence in water should be less than the angle of refraction in air. (1) mark for correct normal (must be placed at the point where a ray meets the water/air boundary)	**3**	Ignore arrows and any labelled angles. Lines should be passably straight. If the normal is not represented as a dotted line it must be labelled.

MARKS DO NOT WRITE IN THIS MARGIN

5. The UV Index is an international standard measurement of the intensity of ultraviolet radiation from the Sun. Its purpose is to help people to effectively protect themselves from UV rays.

The UV index table is shown.

UV Index	*Description*
0 — 2	Low risk from the Sun's UV rays for the average person
3 — 5	Moderate risk of harm from unprotected Sun exposure
6 — 7	High risk of harm from unprotected Sun exposure
8 — 10	Very high risk of harm from unprotected Sun exposure
11+	Extreme risk of harm from unprotected Sun exposure

The UV index can be calculated using

$$\text{UV index} = \left[\begin{array}{c}\text{total effect of}\\ \text{UV radiation}\end{array} \times \begin{array}{c}\text{elevation above}\\ \text{sea level adjustment}\end{array} \times \begin{array}{c}\text{cloud}\\ \text{adjustment}\end{array}\right] \div 25$$

The UV index is then rounded to the nearest whole number.

The tables below give information for elevation above sea level and cloud cover.

Elevation above sea level (km)	*Elevation above sea level adjustment*
1	1·06
2	1·12
3	1·18

Cloud cover	*Cloud adjustment*
Clear skies	1·00
Scattered clouds	0·89
Broken clouds	0·73
Overcast skies	0·31

Back to Table

5. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(a) At a particular location the total effect of UV radiation is 280.

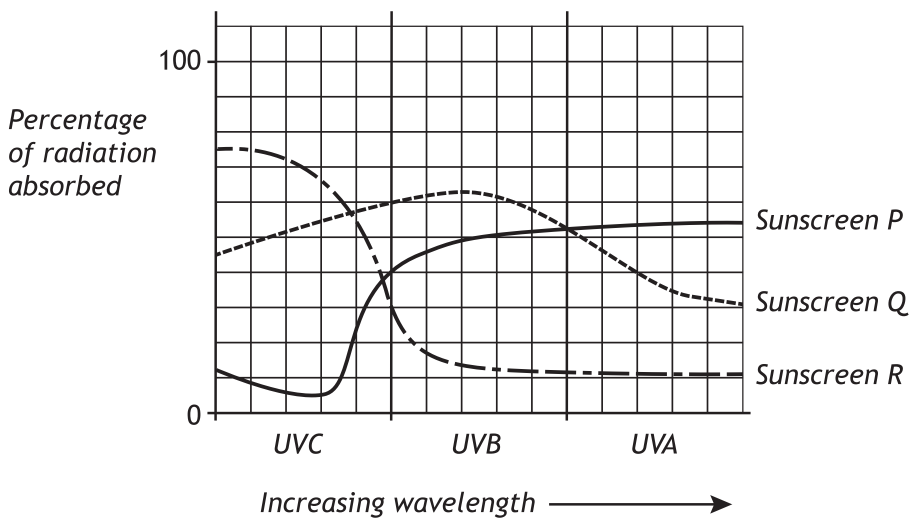
The elevation is 2 km above sea level with overcast skies.

Calculate the UV index value for this location. **2**

Space for working and answer

(b) Applying sunscreen to the skin is one method of protecting people from the Sun's harmful UV rays. UV radiation can be divided into three wavelength ranges, called UVA, UVB and UVC.

A manufacturer carries out some tests on experimental sunscreens P, Q and R to determine how effective they are at absorbing UV radiation. The test results are displayed in the graph.



Using information from the graph, complete the following table. **2**

	UVA	*UVB*	*UVC*
Type of sunscreen that absorbs most of this radiation		Sunscreen Q	
Type of sunscreen that absorbs least of this radiation	Sunscreen R		

(c) State one useful application of UV radiation. **1**

Total marks 5

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Max Mark</th><th>Additional Guidance</th></tr>
<tr><td>5.</td><td>(a)</td><td></td><td>UV index = (total effect of UV radiation x elevation above sea level adjustment x cloud adjustment) ÷ 25

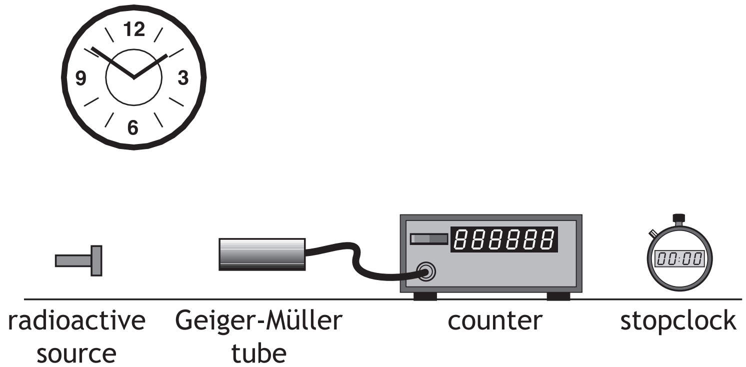
UV index = (280 x 1·12 x 0·31) ÷ 25 (1)

= 3·89

= 4 (1)</td><td>2</td><td>1 mark for substitution
1 mark for final rounded correct answer</td></tr>
<tr><td></td><td>(b)</td><td></td><td><table><tr><td></td><td>UVA</td><td>UVB</td><td>UVC</td></tr><tr><td>Type of sunscreen that absorbs most of this radiation</td><td>P</td><td>Q</td><td>R</td></tr><tr><td>Type of sunscreen that absorbs least of this radiation</td><td>R</td><td>R</td><td>P</td></tr></table></td><td>2</td><td>1 mark for each correct row</td></tr>
<tr><td></td><td>(c)</td><td></td><td>Detecting counterfeit bank notes, setting dental fillings, etc</td><td>1</td><td>Any sensible suggestion
Apply +/- rule</td></tr>
</table>

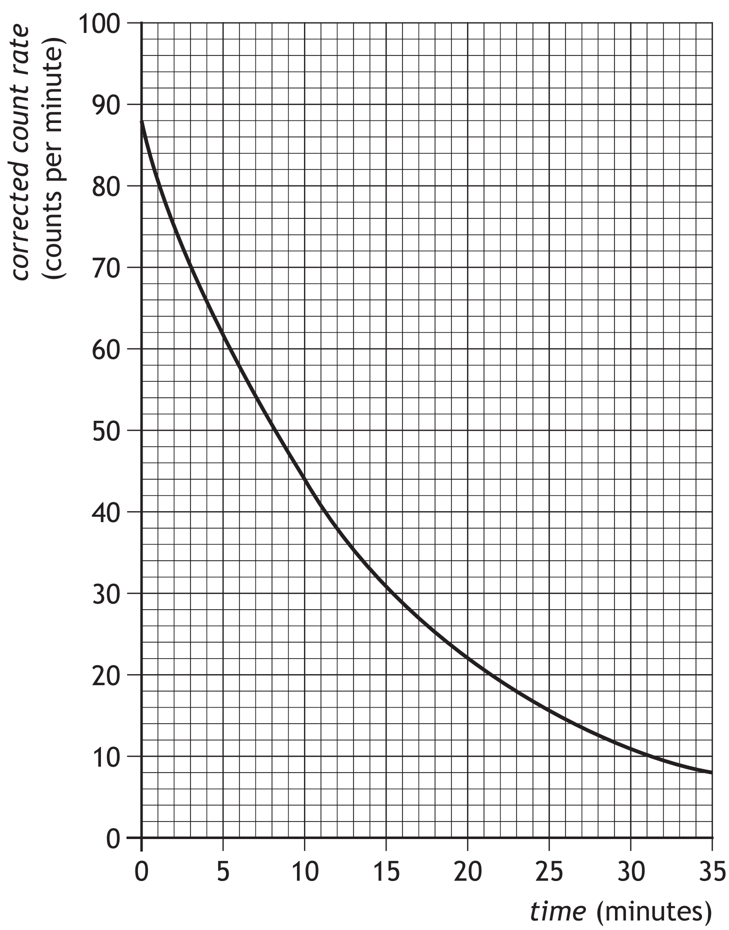
MARKS DO NOT WRITE IN THIS MARGIN

6. A technician carries out an experiment, using the apparatus shown, to determine the half-life of a radioactive source.



(a) State what is meant by the term *half-life*. **1**

(b) The technician displays the data obtained from the experiment in the graph below.



Back to Table

MARKS DO NOT WRITE IN THIS MARGIN

6. (b) (continued)

(i) Describe how the apparatus could be used to obtain the experimental data required to produce this graph. 3

(ii) Use information from the graph to determine the half-life of the radioactive source. 1

(iii) Determine the corrected count rate after 40 minutes. 2

Space for working and answer

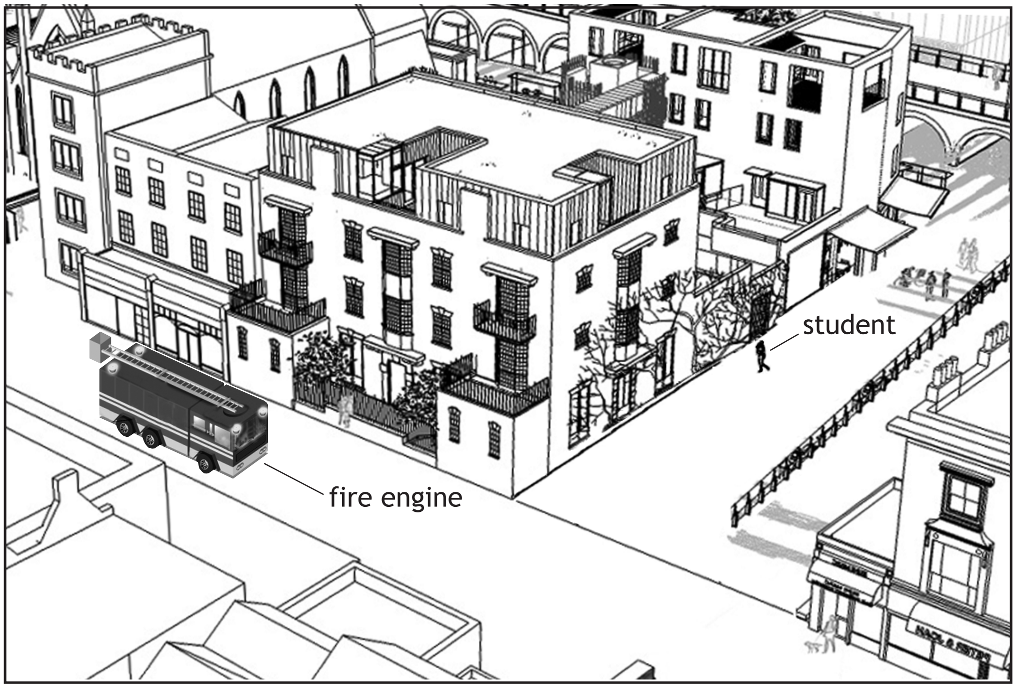
Total marks 7

			Answer	Max Mark	Additional Guidance
6.	(a)		The time taken for the activity / corrected count rate (of a radioactive source) to half.	**1**	Do not accept: Time for radiation / radioactivity / count rate to half.
	(b)	(i)	Measure the count in a set time interval (1) Repeat at (regular) intervals (1) Measure background (count) and subtract (1)	**3**	(3) independent marks. Description must refer to the apparatus shown. If candidate response makes reference to using a rate meter then MAX (2) marks.
	(b)	(ii)	(Half-life =) 10 minutes (1)	**1**	Unit required (accept mins) +/- half box tolerance
		(iii)	$88 \longrightarrow 44 \longrightarrow 22 \longrightarrow 11 \longrightarrow 5{\cdot}5$ (1) mark for evidence of halving Count rate = 5·5 counts per minute (1)	**2**	Or answer consistent with 6(b)(ii) Accept 5 or 6 counts per minute Accept calculation based on one halving of 11 counts per minute Unit required (accept c.p.m.) Alternative method: Accept calculation using division by 2^4 (equivalent to halving).

MARKS | DO NOT WRITE IN THIS MARGIN

7. A fire engine on its way to an emergency is travelling along a main street. The siren on the fire engine is sounding.

A student standing in a nearby street cannot see the fire engine but can hear the siren.



Use your knowledge of physics to comment on why the student can hear the siren even though the fire engine is not in view. **3**

MARKS | DO NOT WRITE IN THIS MARGIN

8. An airport worker passes suitcases through an X-ray machine.

Ints Vikamis/shutterstock.com

(a) The worker has a mass of 80·0 kg and on a particular day absorbs 7·2 mJ of energy from the X-ray machine.

(i) Calculate the absorbed dose received by the worker. **3**

Space for working and answer

(ii) Calculate the equivalent dose received by the worker. **3**

Space for working and answer

Back to Table

MARKS | DO NOT WRITE IN THIS MARGIN

8. (continued)

(b) X-rays can cause ionisation.

Explain what is meant by *ionisation*. **1**

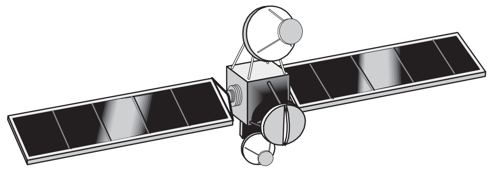
Total marks 7

Back to Table

Question			Answer	Max Mark	Additional Guidance
8.	(a)	(i)	$D=\frac{E}{m}$ (1) $=\frac{7\cdot2\times10^{-3}}{80\cdot0}$ (1) $=9\cdot0\times10^{-5}$ Gy (1)	**3**	
		(ii)	$H=Dw_R$ (1) $=9\cdot0\times10^{-5}\times1$ (1) $=9\cdot0\times10^{-5}$ Sv (1)	**3**	Or answer consistent with 8(a)(i) If wrong radiation weighting factor selected then (1) MAX for correct equation.
	(b)		When an **atom** gains / loses / gains or loses electrons.	**1**	Ignore additional information.

MARKS DO NOT WRITE IN THIS MARGIN

9. A communications satellite is used to transmit live television broadcasts from the UK to Canada.

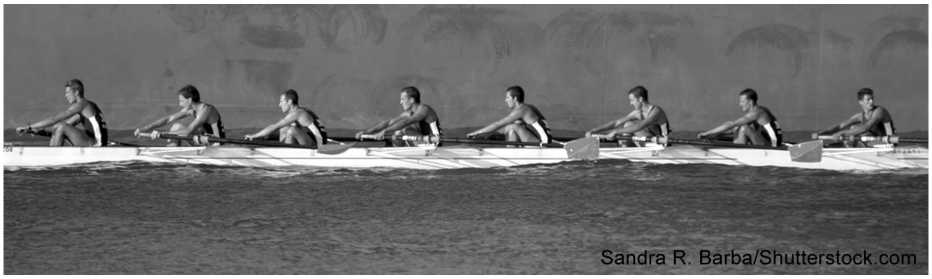


A student states that, to allow the live television broadcasts to be received in Canada, it is important that the satellite does not move.

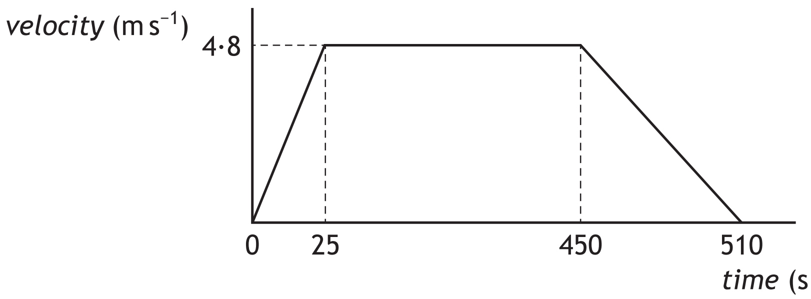
Use your knowledge of physics to comment on this statement. **3**

[Turn over

10. In a rowing event a boat moves off in a straight line.



A graph of the boat's motion is shown.



(a) (i) Calculate the acceleration of the boat during the first 25 s. **3**

Space for working and answer

(ii) Describe the motion of the boat between 25 s and 450 s. **1**

Back to Table

MARKS | DO NOT WRITE IN THIS MARGIN

10. (a) (continued)

(iii) Draw a diagram showing the horizontal forces acting on the boat between 25 s and 450 s.

You **must** name these forces and show their directions. **2**

(b) The boat comes to rest after 510 s.

(i) Calculate the total distance travelled by the boat. **3**

Space for working and answer

(ii) Calculate the average velocity of the boat.

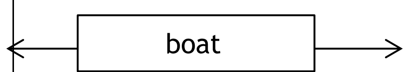
A direction is not required. **3**

Space for working and answer

Total marks 12

Back to Table

[Turn over

Question			Answer	Max Mark	Additional Guidance
10.	(a)	(i)	$a = \frac{v - u}{t}$ (1) $= \frac{4 \cdot 8 - 0}{25}$ (1) $= 0 \cdot 19 \text{ m s}^{-2}$ (1)	**3**	Do not accept: $a = \frac{v}{t}$ s.f. range: 0·19, 0·192, 0·2
		(ii)	constant speed OR constant velocity	**1**	Do not accept: • terminal speed/velocity • “constant” alone • steady speed/velocity
		(iii)	 friction forward force OR  forward force friction	**2**	1 mark for each correctly labelled force and direction For forward force there are other acceptable answers such as thrust, push(ing) (force), etc For friction also accept water resistance, drag. Do not accept: • resistance on its own • air resistance alone • air friction alone Ignore vertical forces.

Question			Answer	Max Mark	Additional Guidance
	(b)	(i)	distance = area under graph (1) $= \left(\frac{1}{2}\times 25\times 4\cdot 8\right) + \left(4\cdot 8\times 425\right)$ $+ \left(\frac{1}{2}\times 60\times 4\cdot 8\right)$ (1) (= 60 + 2040 + 144) $= 2244$ m (1)	**3**	If wrong substitution then (1) MAX for (implied) equation. Any attempt to use s = vt (or d = vt) applied to the **whole** graph (eg 4·8×510) is wrong physics (0) marks. If s = vt (or d = vt) is used correctly for each section of the graph and the results added to give the correct total distance then full marks can be awarded. Ignore incorrect intermediate units eg m^2 s.f. range: 2000 m 2200 m 2240 m 2244 m
		(ii)	*v* = *total distance*/*time* (1) = 2244/510 (1) = 4·4 m s^{-1} (1)	**3**	or consistent with (b)(i)

MARKS DO NOT WRITE IN THIS MARGIN

11. A helicopter is used to take tourists on sightseeing flights.

Information about the helicopter is shown in the table.

weight of empty helicopter	13 500 N
maximum take-off weight	24 000 N
cruising speed	$67\,m\,s^{-1}$
maximum speed	$80\,m\,s^{-1}$
maximum range	610 km

(a) The pilot and passengers are weighed before they board the helicopter.

Explain the reason for this. **1**

(b) Six passengers and the pilot with a combined weight of 6125 N board the helicopter.

Determine the minimum upward force required by the helicopter at take-off. **1**

Space for working and answer

Back to Table

MARKS | DO NOT WRITE IN THIS MARGIN

11. (continued)

(c) The helicopter travels 201 km at its cruising speed.

Calculate the time taken to travel this distance. **3**

Space for working and answer

Total marks 5

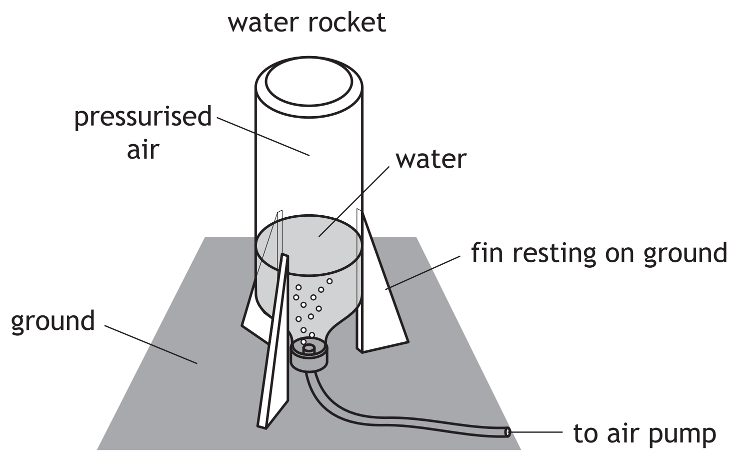
[Turn over

Back to Table

Question			Answer	Max Mark	Additional Guidance
11.	(a)		To check that the maximum take-off weight is not exceeded.	**1**	An indication that the total weight is less than the maximum take-off weight.
	(b)		19 625 N (1)	1	Unit required
	(c)		$d = vt$ (1) $201\,000 = 67 \times t$ (1) $t = 3000$ s (1)	**3**	Accept: 50 minutes / mins

MARKS DO NOT WRITE IN THIS MARGIN

12. A student is investigating the motion of water rockets. The water rocket is made from an upturned plastic bottle containing some water. Air is pumped into the bottle. When the pressure of the air is great enough the plastic bottle is launched upwards.



The mass of the rocket before launch is 0·94 kg.

(a) Calculate the weight of the water rocket. **3**

Space for working and answer

(b) Before launch, the water rocket rests on three fins on the ground.

The area of each fin in contact with the ground is $2{\cdot}0 \times 10^{-4}\,m^2$.

Calculate the total pressure exerted on the ground by the fins. **4**

Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

12. (continued)

(c) Use Newton's Third Law to explain how the rocket launches. **1**

(d) At launch, the initial upward thrust on the rocket is 370 N.

Calculate the initial acceleration of the rocket. **4**

Space for working and answer

(e) The student launches the rocket a second time.

For this launch, the student adds a greater volume of water than before.

The same initial upward thrust acts on the rocket but it fails to reach the same height.

Explain why the rocket fails to reach the same height. **2**

Total marks 14

[END OF QUESTION PAPER]

Question			Answer	Max Mark	Additional Guidance
12.	(a)		$W = mg$ (1) $= 0 \cdot 94 \times 9 \cdot 8$ (1) $= 9 \cdot 2$ N (1)	**3**	Do not accept 10 or 9·81 for g s.f. range: 9 N, 9·2 N, 9·21 N, 9·212 N Do not accept 9·0 N
	(b)		**Method 1** $A = 3 \times \left(2 \cdot 0 \times 10^{-4}\right)$ $= 6 \cdot 0 \times 10^{-4}$ (m^2) (1) $p = \frac{F}{A}$ (1) $= \frac{9 \cdot 2}{6 \cdot 0 \times 10^{-4}}$ (1) $= 1 \cdot 5 \times 10^{4}$ Pa (1) **Method 2** $p = \frac{F}{A}$ (1) $= \frac{9 \cdot 2}{2 \cdot 0 \times 10^{-4}}$ (1) $= 4 \cdot 6 \times 10^{4}$ (Pa) (1) (If this line is the candidate's final answer, unit required.) total $p = \frac{4 \cdot 6 \times 10^{4}}{3}$ $= 1 \cdot 5 \times 10^{4}$ Pa (1) **Method 3…** Alternative – take 1/3 of weight and use this for *F* in *p* = *F*/*A*	**4**	or consistent with (a) Each method requires to multiply or divide by 3. This can appear at any stage in the candidate response, but if this does not appear then MAX (3) marks. s.f. range: 1-4 if 9·2 used, 20 000, 15 000, 15 300, 15 330 s.f. range: 1-4 if 9·21 used, 20 000, 15 000, 15 400, 15 350 s.f. range: 1-4 if 9·212 used, 20 000, 15 000, 15 400, 15 350

Question			Answer	Max Mark	Additional Guidance
	(c)		Rocket / bottle pushes down on water, water pushes up on rocket / bottle	**1**	
	(d)		F_{un} = upthrust — weight = 370 — 9·2 = 360·8 (N) (1) $a = \frac{F}{m}$ (1) $= \frac{360 \cdot 8}{0 \cdot 94}$ (1) $= 380 \text{ m s}^{-2}$ (1)	**4**	or consistent with (a) If arithmetic error in calculation of F_{un}, then MAX (3) marks. If no attempt made at calculation of F_{un}, then MAX (1) mark for equation. s.f. range for 9·2, 9·21, 9·212: (400, 380, 384, 383·8)
	(e)		• more water will increase weight/mass (1) • unbalanced force decreases (1) • acceleration is less (1)	**2**	Any two from three. Do not accept: • heavier

[END OF MARKING INSTRUCTIONS]

N5 National Qualifications 2015

X757/75/02

Physics
Section 1—Questions

TUESDAY, 5 MAY

9:00 AM – 11:00 AM

Instructions for the completion of Section 1 are given on *Page two* of your question and answer booklet X757/75/01.

Record your answers on the answer grid on *Page three* of your question and answer booklet.

Reference may be made to the Data Sheet on *Page two* of this booklet and to the Relationship Sheet X757/75/11.

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

* X 7 5 7 7 5 0 2 *

Back to Table

DATA SHEET

Speed of light in materials

Material	*Speed* in m s^{-1}
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	$2{\cdot}3 \times 10^8$

Gravitational field strengths

	Gravitational field strength on the surface in N kg^{-1}
Earth	9·8
Jupiter	23
Mars	3·7
Mercury	3·7
Moon	1·6
Neptune	11
Saturn	9·0
Sun	270
Uranus	8·7
Venus	8·9

Specific latent heat of fusion of materials

Material	*Specific latent heat of fusion* in J kg^{-1}
Alcohol	$0{\cdot}99 \times 10^5$
Aluminium	$3{\cdot}95 \times 10^5$
Carbon Dioxide	$1{\cdot}80 \times 10^5$
Copper	$2{\cdot}05 \times 10^5$
Iron	$2{\cdot}67 \times 10^5$
Lead	$0{\cdot}25 \times 10^5$
Water	$3{\cdot}34 \times 10^5$

Specific latent heat of vaporisation of materials

Material	*Specific latent heat of vaporisation* in J kg^{-1}
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	$22{\cdot}6 \times 10^5$

Speed of sound in materials

Material	*Speed* in m s^{-1}
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Specific heat capacity of materials

Material	*Specific heat capacity* in J kg^{-1} °C^{-1}
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Ice	2100
Iron	480
Lead	128
Oil	2130
Water	4180

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
Iron	1537	2737

Radiation weighting factors

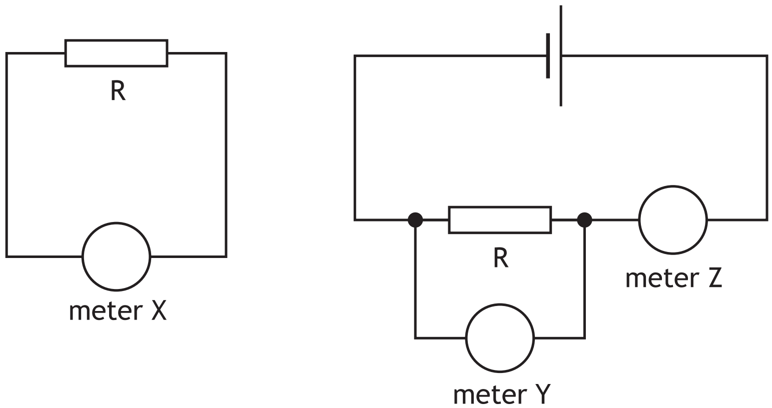
Type of radiation	*Radiation weighting factor*
alpha	20
beta	1
fast neutrons	10
gamma	1
slow neutrons	3
X-rays	1

Back to Table

SECTION 1

Attempt ALL questions

1. Two circuits are set up as shown.



Both circuits are used to determine the resistance of resistor R.

Which row in the table identifies meter X, meter Y and meter Z?

	meter X	*meter Y*	*meter Z*
A	ohmmeter	voltmeter	ammeter
B	ohmmeter	ammeter	voltmeter
C	voltmeter	ammeter	ohmmeter
D	ammeter	voltmeter	ohmmeter
E	voltmeter	ohmmeter	ammeter

2. Which of the following statements is/are correct?

I The voltage of a battery is the number of joules of energy it gives to each coulomb of charge.

II A battery only has a voltage when it is connected in a complete circuit.

III Electrons are free to move within an insulator.

A I only

B II only

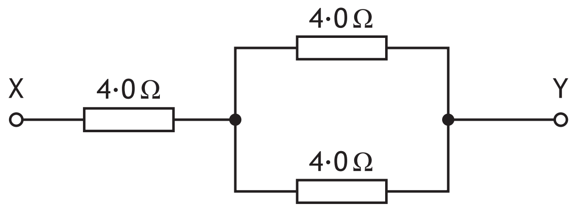
C III only

D II and III only

E I, II and III

[Turn over

3. A circuit is set up as shown.



The resistance between X and Y is

A 1·3 Ω

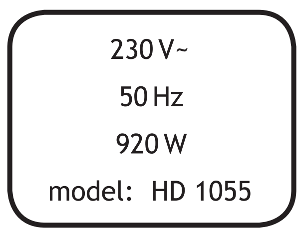
B 4·5 Ω

C 6·0 Ω

D 8·0 Ω

E 12 Ω.

4. The rating plate on an electrical appliance is shown.



The resistance of this appliance is

A 0·017 Ω

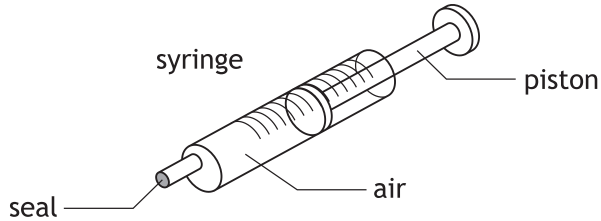
B 0·25 Ω

C 4·0 Ω

D 18·4 Ω

E 57·5 Ω.

5. A syringe containing air is sealed at one end as shown.



The piston is pushed in slowly.

There is no change in temperature of the air inside the syringe.

Which of the following statements describes and explains the change in pressure of the air in the syringe?

A The pressure increases because the air particles have more kinetic energy.

B The pressure increases because the air particles hit the sides of the syringe more frequently.

C The pressure increases because the air particles hit the sides of the syringe less frequently.

D The pressure decreases because the air particles hit the sides of the syringe with less force.

E The pressure decreases because the air particles have less kinetic energy.

6. The pressure of a fixed mass of gas is 150 kPa at a temperature of 27 °C.

The temperature of the gas is now increased to 47 °C.

The volume of the gas remains constant.

The pressure of the gas is now

A 86 kPa

B 141 kPa

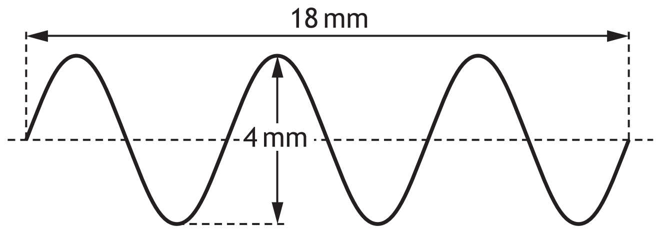
C 150 kPa

D 160 kPa

E 261 kPa.

[Turn over

7. The diagram represents a water wave.



The wavelength of the water wave is

A 2 mm

B 3 mm

C 4 mm

D 6 mm

E 18 mm.

8. A student makes the following statements about different types of electromagnetic waves.

I Light waves are transverse waves.

II Radio waves travel at $340\,m\,s^{-1}$ through air.

III Ultraviolet waves have a longer wavelength than infrared waves.

Which of these statements is/are correct?

A I only

B I and II only

C I and III only

D II and III only

E I, II and III

9. Alpha radiation ionises an atom.

Which statement describes what happens to the atom?

A The atom splits in half.

B The atom releases a neutron.

C The atom becomes positively charged.

D The atom gives out gamma radiation.

E The atom releases heat.

10. A sample of tissue is irradiated using a radioactive source.

A student makes the following statements.

The equivalent dose received by the tissue is

I reduced by shielding the tissue with a lead screen

II increased as the distance from the source to the tissue is increased

III increased by increasing the time of exposure of the tissue to the radiation.

Which of the statements is/are correct?

A I only

B II only

C I and II only

D II and III only

E I and III only

11. A sample of tissue receives an absorbed dose of 16 μGy from alpha particles.

The radiation weighting factor for alpha particles is 20.

The equivalent dose received by the sample is

A 0·80 μSv

B 1·25 μSv

C 4 μSv

D 36 μSv

E 320 μSv.

12. For a particular radioactive source, 240 atoms decay in 1 minute.

The activity of this source is

A 4 Bq

B 180 Bq

C 240 Bq

D 300 Bq

E 14 400 Bq.

[Turn over

Back to Table

13. The letters **X, Y** and **Z** represent missing words from the following passage.

During a nuclear ……**X**…… *reaction two nuclei of smaller mass number combine to produce a nucleus of larger mass number. During a nuclear* ……**Y**…… *reaction a nucleus of larger mass number splits into two nuclei of smaller mass number. Both of these reactions are important because these processes can release* ……**Z**…… .

Which row in the table shows the missing words?

	X	*Y*	*Z*
A	fusion	fission	electrons
B	fission	fusion	energy
C	fusion	fission	protons
D	fission	fusion	protons
E	fusion	fission	energy

14. Which of the following quantities is fully described by its magnitude?

A Force

B Displacement

C Energy

D Velocity

E Acceleration

15. The table shows the velocities of three objects X, Y and Z over a period of 3 seconds. Each object is moving in a straight line.

Time (s)	0	1	2	3
Velocity of X ($m\,s^{-1}$)	2	4	6	8
Velocity of Y ($m\,s^{-1}$)	0	1	2	3
Velocity of Z ($m\,s^{-1}$)	0	2	5	9

Which of the following statements is/are correct?

I X moves with constant velocity.

II Y moves with constant acceleration.

III Z moves with constant acceleration.

A I only

B II only

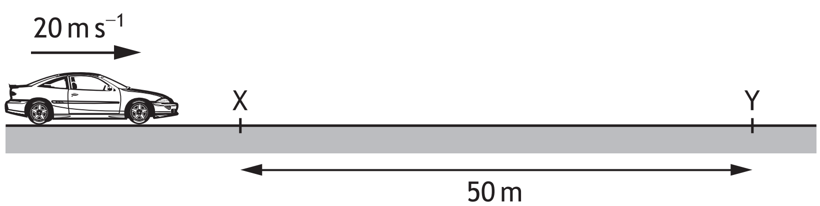
C I and II only

D I and III only

E II and III only

16. A car of mass 1200 kg is travelling along a straight level road at a constant speed of $20\,m\,s^{-1}$.

The driving force on the car is 2500 N. The frictional force on the car is 2500 N.



The work done moving the car between point X and point Y is

A 0 J

B 11 800 J

C 125 000 J

D 240 000 J

E 250 000 J.

[Turn over

17. A person sits on a chair which rests on the Earth. The person exerts a downward force on the chair.

Which of the following is the reaction to this force?

A The force of the chair on the person

B The force of the person on the chair

C The force of the Earth on the person

D The force of the chair on the Earth

E The force of the person on the Earth

18. A package falls vertically from a helicopter. After some time the package reaches its terminal velocity.

A group of students make the following statements about the package when it reaches its terminal velocity.

I The weight of the package is less than the air resistance acting on the package.

II The forces acting on the package are balanced.

III The package is accelerating towards the ground at $9{\cdot}8\,\mathrm{m\,s^{-2}}$.

Which of these statements is/are correct?

A I only

B II only

C III only

D I and III only

E II and III only

19. The distance from the Sun to Proxima Centauri is 4·3 light years.

This distance is equivalent to

A $1{\cdot}4 \times 10^{8}$ m

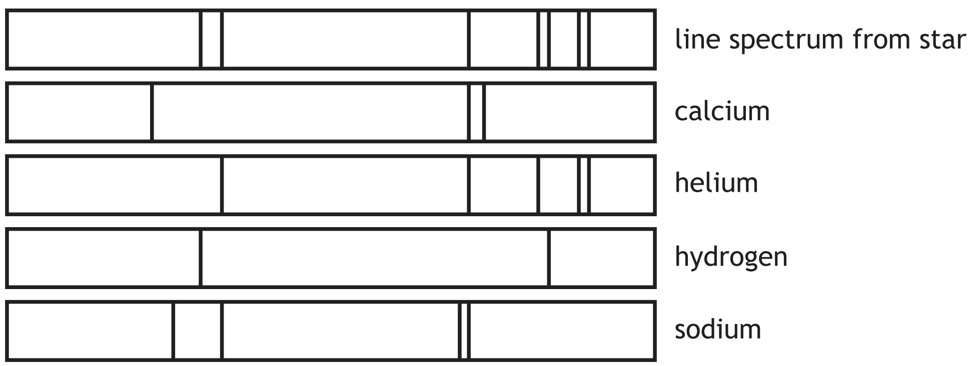
B $1{\cdot}6 \times 10^{14}$ m

C $6{\cdot}8 \times 10^{14}$ m

D $9{\cdot}5 \times 10^{15}$ m

E $4{\cdot}1 \times 10^{16}$ m.

20. Light from a star is split into a line spectrum of different colours. The line spectrum from the star is shown, along with the line spectra of the elements calcium, helium, hydrogen and sodium.



The elements present in this star are

A sodium and calcium

B calcium and helium

C hydrogen and sodium

D helium and hydrogen

E calcium, sodium and hydrogen.

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET]

Detailed Marking Instruction for each Question

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

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N5

National Qualifications 2015

Mark

X757/75/01

Physics Section 1—Answer Grid and Section 2

TUESDAY, 5 MAY

9:00 AM – 11:00 AM

* X 7 5 7 7 5 0 1 *

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 — 110

SECTION 1 — 20 marks

Attempt ALL questions.

Instructions for the completion of Section 1 are given on *Page two*.

SECTION 2 — 90 marks

Attempt ALL questions.

Reference may be made to the Data Sheet on *Page two* of the question paper X757/75/02 and to the Relationship Sheet X757/75/11.

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.

SQA

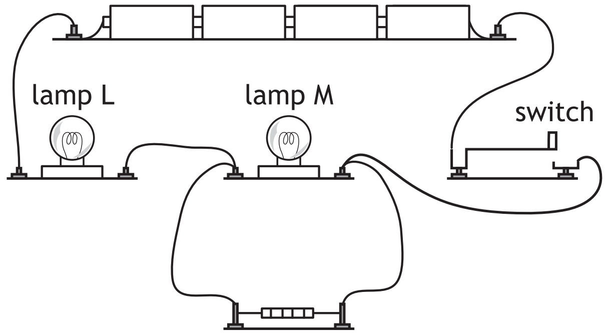
* X 7 5 7 7 5 0 1 0 1 *

SECTION 2 — 90 marks

Attempt ALL questions

MARKS | DO NOT WRITE IN THIS MARGIN

1. A student sets up the following circuit using a battery, two lamps, a switch and a resistor.



(a) Draw a circuit diagram for this circuit using the correct symbols for the components. **3**

(b) Each lamp is rated 2·5 V, 0·50 A.

Calculate the resistance of one of the lamps when it is operating at the correct voltage. **3**

Space for working and answer

MARKS DO NOT WRITE IN THIS MARGIN

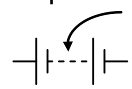
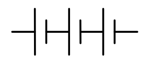
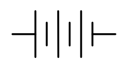
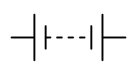
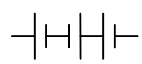
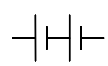
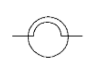
1. (continued)

(c) When the switch is closed, will lamp L be brighter, dimmer or the same brightness as lamp M?

You **must** justify your answer. **3**

[Turn over

Section 2

Question			Answer	Max Mark	Additional Guidance
1.	(a)		2 marks for symbols: • All correct (2) • At least two different symbols correct (1) 1 mark for correct representation of external circuit wiring with no gaps	**3**	Must be three or more cells with consistent polarity or a battery symbol. i.e. Accept: must have at least two dashes   minimum of 3 cells  minimum of 3 cells or any of these reversed Do not accept:  incorrect symbol  polarity not consistent  only two cells line not dashed Ignore any labelling. Accept  for bulb. Accept  for resistor. Mark for circuit wiring dependent on at least one of the two marks for symbols.
	(b)		$V = IR$ (1) $2 \cdot 5 = 0 \cdot 5 \times R$ (1) $R = 5\ \Omega$ (1)	**3**	Or by an appropriate alternative method.

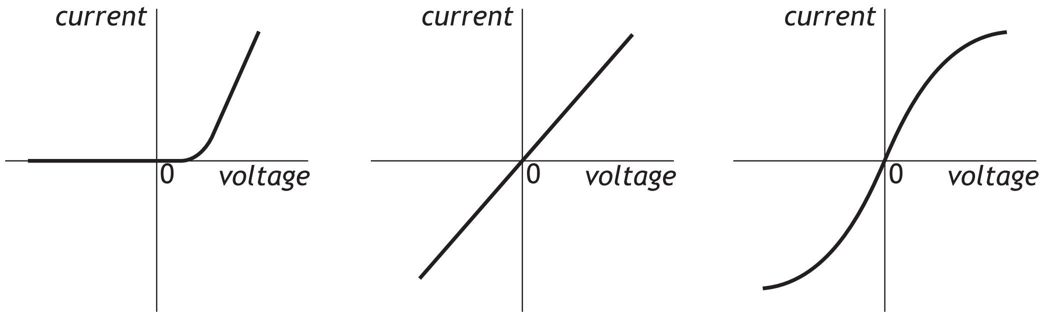
Question			Answer	Max Mark	Additional Guidance
	(c)		**Effect:** (It/lamp L is) brighter (1) **Justification:** M is in <u>parallel</u> (with resistor) (1) Greater current in/through lamp L (than that in M) (1) **OR** **Effect:** (It/lamp L is) brighter (1) **Justification:** M is in <u>parallel</u> (with resistor) (1) Greater voltage across lamp L (than across M) (1)	**3**	First mark can only be awarded if a justification is attempted. Effect correct + justification correct (3) Effect correct + justification partially correct (2) Effect correct + justification incorrect (1) Effect correct + no justification attempted (0) Incorrect or no effect stated regardless of justification (0) Accept an implication of current greater in L because 'it splits up between M and the resistor' Do not accept: • 'current going to lamp' • 'current across lamp' • 'voltage through lamp' Accept correct effect on lamp M eg' <u>Lamp M</u> is dimmer' Accept converse justifications eg 'current in lamp M is less than lamp L'

Back to Table

MARKS DO NOT WRITE IN THIS MARGIN

2. (a) A student investigates the electrical properties of three different components; a lamp, an LED and a fixed resistor.

Current-voltage graphs produced from the student's results are shown.



Graph X Graph Y Graph Z

Explain which graph X, Y or Z is obtained from the student's results for the LED. **2**

(b) One of the components is operated at 4·0 V with a current of 0·50 A for 60 seconds.

(i) Calculate the energy transferred to the component during this time. **4**

Space for working and answer

X757750108

Back to Table

MARKS DO NOT WRITE IN THIS MARGIN

2. (b) (continued)

(ii) Calculate the charge which passes through this component during this time. **3**

Space for working and answer

[Turn over

Back to Table

Question			Answer	Max Mark	Additional Guidance
2.	(a)		(Graph) X (1) An LED/diode/it only conducts in one direction (1)	**2**	Not independent marks - mark for explanation can only be accessed if graph X is identified. 'X' alone (1)
	(b)	(i)	$P = IV$ (1) $P = 0 \cdot 5 \times 4$ $P = 2$ (W) $E = Pt$ (1) $E = 2 \times 60$ (1) $E = 120$ J (1)	**4**	(1) for each formula (1) for correct substitutions of *I*, *V* and *t* (1) final answer and unit Alternative method: $E = ItV$ (1)+(1) $E = 0 \cdot 5 \times 4 \times 60$ (1) $E = 120$ J (1)
	(b)	(ii)	$Q = I \times t$ (1) $Q = 0 \cdot 5 \times 60$ (1) $Q = 30\ C$ (1)	**3**	

3. A technician uses pulses of ultrasound (high frequency sound) to detect imperfections in a sample of steel.

The pulses of ultrasound are transmitted into the steel.

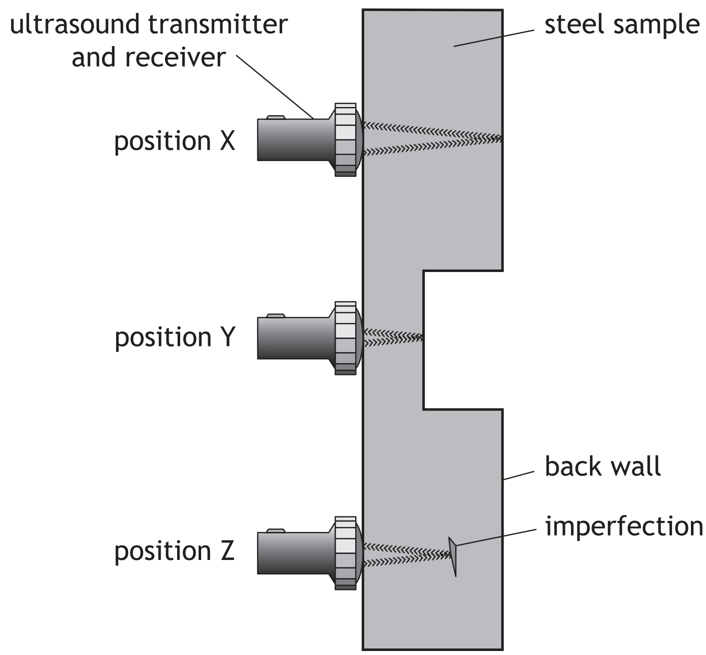
The speed of ultrasound in steel is $5200\,m\,s^{-1}$.

Where there are no imperfections, the pulses of ultrasound travel through the steel and are reflected by the back wall of the steel.

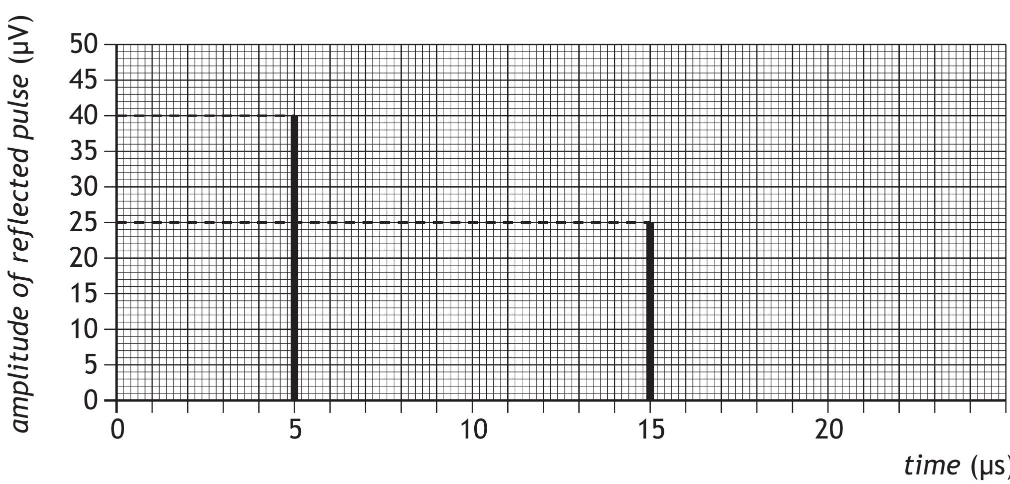
Where there are imperfections in the steel, the pulses of ultrasound are reflected by these imperfections.

The reflected pulses return through the sample and are detected by the ultrasound receiver.

The technician transmits pulses of ultrasound into the steel at positions X, Y and Z as shown.



The times between the pulses being transmitted and received for positions X and Y are shown in the graph.



3. (continued) MARKS DO NOT WRITE IN THIS MARGIN

(a) (i) State the time taken between the pulse being transmitted and received at position X. **1**

(ii) Calculate the thickness of the steel sample at position X. **4**

Space for working and answer

(b) On the graph on the previous page, draw a line to show the reflected pulse from position Z. **2**

(c) The ultrasound pulses used have a period of 4·0 μs.

(i) Show that the frequency of the ultrasound pulses is $2{\cdot}5 \times 10^5$ Hz. **2**

Space for working and answer

(ii) Calculate the wavelength of the ultrasound pulses in the steel sample. **3**

Space for working and answer

X757750111

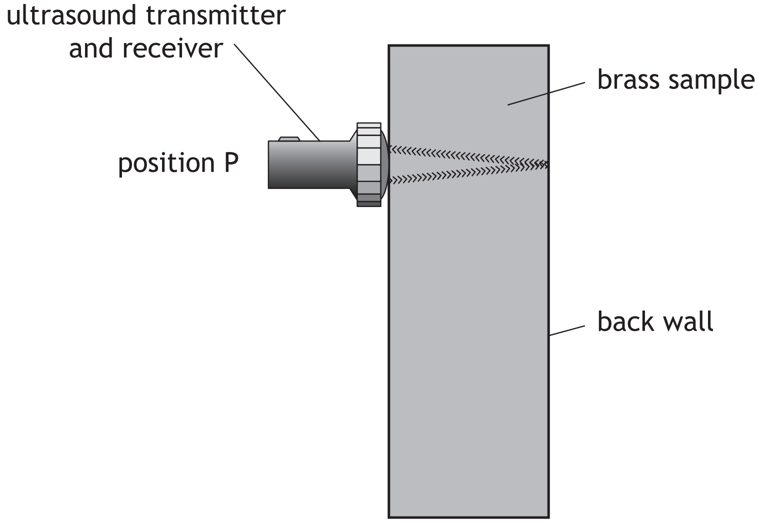
MARKS | DO NOT WRITE IN THIS MARGIN

3. (continued)

(d) The technician replaces the steel sample with a brass sample.

The brass sample has the same thickness as the steel sample at position X.

The technician transmits pulses of ultrasound into the brass at position P as shown.

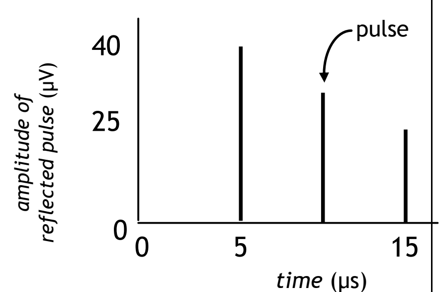


The time between the ultrasound pulse being transmitted and received at position P is greater than the time recorded at position X in the steel sample.

State whether the speed of ultrasound in brass is less than, equal to or greater than the speed of ultrasound in steel.

You **must** justify your answer. **2**

X757750112

Question			Answer	Max Mark	Additional Guidance
3.	(a)	(i)	15 μs	**1**	Must have correct unit 'μs' not 'us' Accept numerical equivalent (eg 15×10^{-6} s)
		(ii)	**Method 1:** $d = v\,t$ (1) $= 5200 \times 15 \times 10^{-6}$ (1) $= 0\cdot078\ (\text{m})$ (1) (If this line is the candidate's final answer, unit required) $\textit{thickness} = \dfrac{0\cdot078}{2}$ $= 0\cdot039\text{ m}$ (1) **Method 2:** $\textit{time} = \dfrac{15\times10^{-6}}{2}$ $= 7\cdot5\times10^{-6}\ (\text{s})$ (1) $d = v\,t$ (1) $= 5200 \times 7\cdot5\times10^{-6}$ (1) $= 0\cdot039\text{ m}$ (1)	**4**	Or consistent with (a)(i) Accept 0·04 m Each method requires to divide by 2. This can appear at any stage in the candidate response, but if this does not appear then MAX (3)
	(b)			**2**	The reflected pulse for position Z should be shown as: • a peak at a time greater than 5 μs and less than 15 μs. • an amplitude greater than 25 μV and less than 40 μV. (1) for each of the above features - independent marks Ignore any horizontal lines

Question			Answer	Max Mark	Additional Guidance
	(c)	(i)	** SHOW THAT ** Must start with the correct formula or (0) $f = \frac{1}{T}$ (1) $= \frac{1}{4 \cdot 0 \times 10^{-6}}$ (1) $= 2 \cdot 5 \times 10^{5}$ Hz	**2**	Final answer of $2{\cdot}5 \times 10^{5}$ Hz or its numerical equivalent, including unit, must be shown, otherwise a maximum of (1) can be awarded. Alternative method: $T = \frac{1}{f}$ (1) $= \frac{1}{2 \cdot 5 \times 10^{5}}$ (1) $= 4 \cdot 0 \times 10^{-6}$ s This is the same as the period (of the ultrasound pulse) For the alternative method, the final statement **must** be included; otherwise a maximum of (1) can be awarded.
		(ii)	$v = f\lambda$ (1) $5200 = 2 \cdot 5 \times 10^{5} \times \lambda$ (1) $\lambda = 0 \cdot 021$ m (1)	**3**	Accept: 0·02 m 0·021 m 0·0208 m Must use frequency value of $2{\cdot}5 \times 10^{5}$ Hz.

Question			Answer	Max Mark	Additional Guidance
	(d)		(Speed of ultrasound in brass is) less (than in steel). (1) Takes greater time to travel (same) distance/thickness. (1)	**2**	First mark can only be awarded if a justification is attempted. Effect correct + justification correct (2) Effect correct + justification incorrect (1) Effect correct + no justification attempted (0) Incorrect or no effect stated regardless of justification (0) Must link increased time and same distance/ thickness for justification mark. Could be done by reference to a formula. Accept: 'slower' Do not accept up/down arrows in place of words.

MARKS DO NOT WRITE IN THIS MARGIN

4. A science technician removes two metal blocks from an oven. Immediately after the blocks are removed from the oven the technician measures the temperature of each block, using an infrared thermometer. The temperature of each block is 230 °C.

After several minutes the temperature of each block is measured again. One block is now at a temperature of 123 °C and the other block is at a temperature of 187 °C.

Using your knowledge of physics, comment on possible explanations for this difference in temperature. **3**

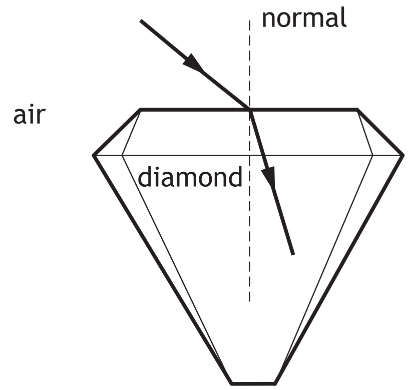
[Turn over

* X 7 5 7 7 5 0 1 1 3 *

5. Diamonds are popular and sought after gemstones.

Light is refracted as it enters and leaves a diamond.

The diagram shows a ray of light entering a diamond.



(a) On the diagram, label the angle of incidence *i* and the angle of refraction *r*. **1**

(b) State what happens to the speed of the light as it enters the diamond. **1**

(c) The optical density of a gemstone is a measure of its ability to refract light.

Gemstones of higher optical density cause more refraction.

A ray of light is directed into a gemstone at an angle of incidence of 45°.

The angle of refraction is then measured.

This is repeated for different gemstones.

Gemstone	*Angle of refraction*
A	24·3°
B	17·0°
C	27·3°
D	19·0°
E	25·5°

Diamond is known to have the highest optical density.

Identify which gemstone is most likely to be diamond. **1**

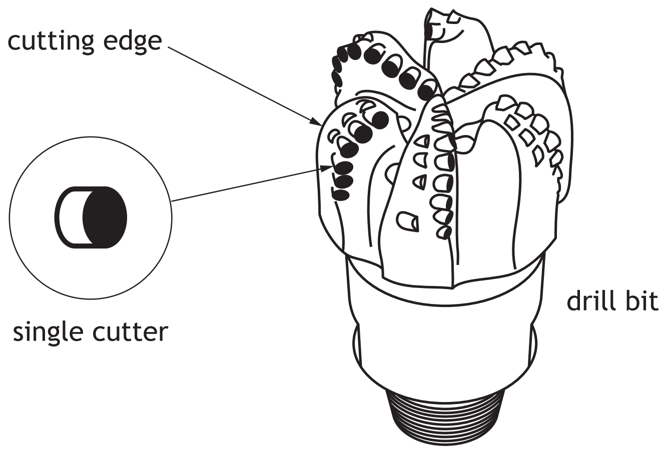
MARKS DO NOT WRITE IN THIS MARGIN

5. (continued)

(d) Diamond is one of the hardest known substances.

Synthetic diamonds are attached to the cutting edges of drill bits for use in the oil industry.

These drill bits are able to cut into rock.



The area of a single cutter in contact with the rock is $1{\cdot}1 \times 10^{-5}\,m^2$.

When drilling, this cutter is designed to exert a maximum force of 61 kN on the rock.

Calculate the maximum pressure that the cutter can exert on the rock. **3**

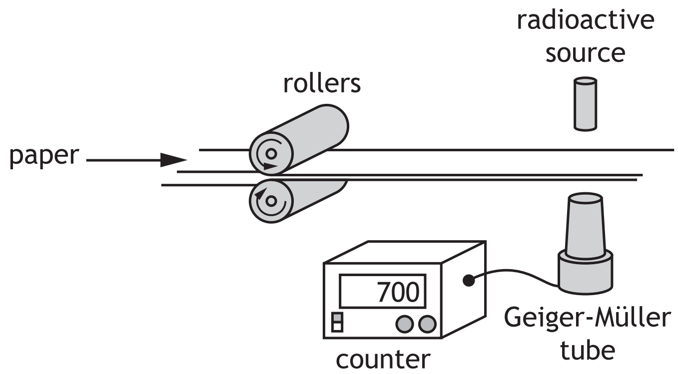
Space for working and answer

[Turn over

Question			Answer	Max	Additional Guidance
5.	(a)		Correctly labelled the angle of incidence **and** angle of refraction	**1**	No need for arcs. Can use words or symbols, *I*, θ_i etc.
	(b)		Decreases	**1**	Accept: 'slows down' 'changes to $1{\cdot}2 \times 10^8$ m s^{-1}' Do not accept: 'changes' alone
	(c)		B	**1**	Or clearly identified, eg circled in table
	(d)		$P = \frac{F}{A}$ (1) $= \frac{61000}{1{\cdot}1 \times 10^{-5}}$ (1) $= 5{\cdot}5 \times 10^9$ Pa (1)	**3**	Accept N m^{-2} Accept 1-4 sig fig: 6×10^9 Pa $5{\cdot}5 \times 10^9$ Pa $5{\cdot}55 \times 10^9$ Pa $5{\cdot}545 \times 10^9$ Pa

MARKS DO NOT WRITE IN THIS MARGIN

6. A paper mill uses a radioactive source in a system to monitor the thickness of paper.



Radiation passing through the paper is detected by the Geiger-Müller tube. The count rate is displayed on the counter as shown. The radioactive source has a half-life that allows the system to run continuously.

(a) State what happens to the count rate if the thickness of the paper decreases. **1**

(b) The following radioactive sources are available.

Radioactive Source	*Half-life*	*Radiation emitted*
W	600 years	alpha
X	50 years	beta
Y	4 hours	beta
Z	350 years	gamma

(i) State which radioactive source should be used.

You **must** explain your answer. **3**

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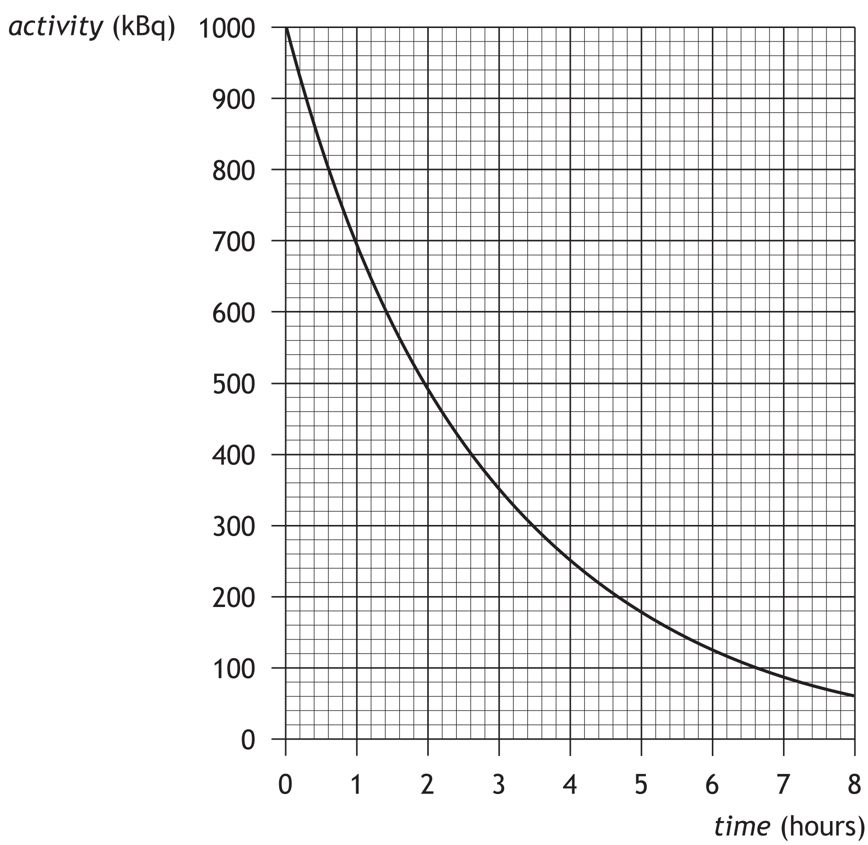
MARKS | DO NOT WRITE IN THIS MARGIN

6. (b) (continued)

(ii) State what is meant by the term *half-life*. **1**

(iii) State what is meant by a gamma ray. **1**

(c) The graph below shows how the activity of another radioactive source varies with time.



Determine the half-life of this radioactive source. **1**

[Turn over

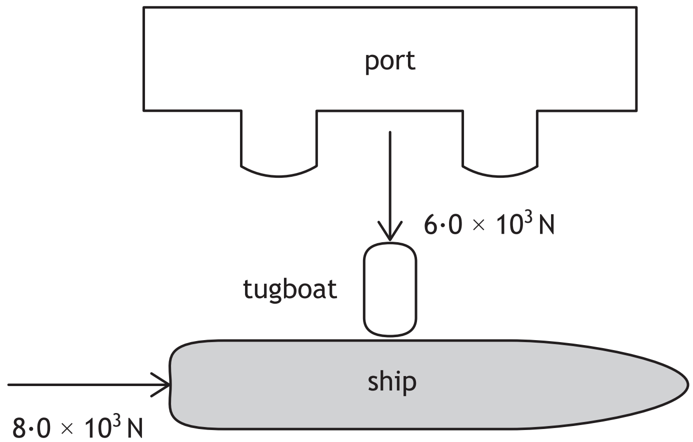
X757750117

Question			Answer	Max Mark	Additional Guidance
6.	(a)		Increases	**1**	
	(b)	(i)	**Choice:** (source) X (1) **Explanation:** beta (source required) (1) long half-life (1)	**3**	First mark can only be awarded if an explanation is attempted. Choice correct + explanation correct (3) Choice correct + explanation partially correct (2) Choice correct + explanation incorrect (1) Choice correct + no explanation attempted (0) Incorrect or no choice made regardless of explanation (0) Having chosen source X, can explain why each of the other three sources should not be used. Having chosen source X, can explain that a beta source should be used but that source Y is not suitable because it has too short a half-life.
		(ii)	Time for activity to (decrease by) half **OR** Time for half the nuclei to decay	**1**	Do not accept: Time for radiation/radioactivity/ count rate to half

Question			Answer	Max Mark	Additional Guidance
		(iii)	(high frequency) electromagnetic wave	**1**	Accept: 'EM wave' '(high energy) photon' 'electromagnetic radiation' Do not accept: 'electromagnetic ray' 'part of the electromagnetic spectrum' 'transverse wave' Ignore additional information
	(c)		2 hours	**1**	Unit required Accept 1·9 to 2·1 h

MARKS | DO NOT WRITE IN THIS MARGIN

7. A ship of mass $5{\cdot}0 \times 10^6$ kg leaves a port. Its engine produces a forward force of $8{\cdot}0 \times 10^3$ N. A tugboat pushes against one side of the ship as shown. The tugboat applies a pushing force of $6{\cdot}0 \times 10^3$ N.



(a) (i) By scale drawing, or otherwise, determine the size of the resultant force acting on the ship. **2**

Space for working and answer

(ii) Determine the direction of the resultant force relative to the $8{\cdot}0 \times 10^3$ N force. **2**

Space for working and answer

* X 7 5 7 7 5 0 1 1 8 *

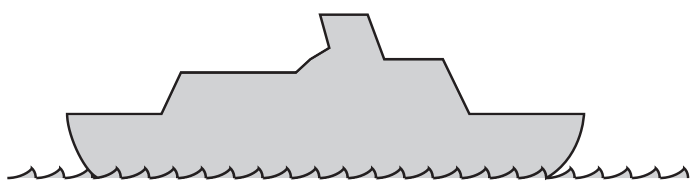
MARKS | DO NOT WRITE IN THIS MARGIN

7. (a) (continued)

(iii) Calculate the size of the acceleration of the ship. **3**

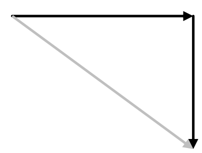
Space for working and answer

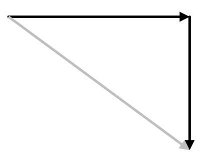
(b) Out in the open sea the ship comes to rest.

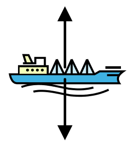


Explain, with the aid of a labelled diagram, why the ship floats. **3**

[Turn over

Question			Answer	Max Mark	Additional Guidance
7.	(a)	(i)	**Using Pythagoras:** Resultant^2 = $(6{\cdot}0 \times 10^3)^2 + (8{\cdot}0 \times 10^3)^2$ (1) Resultant = 10×10^3 N (1) **Using scale diagram:**  vectors to scale (1) Resultant = 10×10^3 N (1) (allow $\pm 0{\cdot}5\times 10^3$ N tolerance)	2	Regardless of method, if a candidate shows a vector diagram (or a representation of a vector diagram eg a triangle with no arrows) and the **vectors have been represented incorrectly**, eg head-to-head then MAX (1) Ignore any direction stated in the final answer in this part. can obtain first mark for scale diagram method from suitable diagram in part (a) (ii) if not drawn in this part

Question			Answer	Max Mark	Additional Guidance
		(ii)	**Using trigonometry:** tan θ = 6/8 (1) θ = 37° (1) **Using scale diagram:**  angles correct (1) θ = 37° (1) (allow ±2° tolerance)	**2**	Or use of resultant value consistent with (a)(i) Regardless of method, if a candidate (re)draws a vector diagram (or a representation of a vector diagram eg a triangle with no arrows) in this part and the **vectors have been represented incorrectly**, eg head-to-head then MAX (1) Can also do with other trig functions: sin θ = 6/10 cos θ = 8/10 allow 1-4 sig fig: 40° 37° 36·9° 36·87° Must be an attempt to calculate the angle relative to the $8{\cdot}0 \times 10^3$ N force. ie Can use trig method to calculate the complementary angle, but must subtract this from 90° otherwise (0) If a candidate calculates or determines the 37° then goes on to express this as a three figure bearing MAX (1) Any reference to compass points in final answer is incorrect – MAX (1) can obtain first mark for scale diagram method from suitable diagram in part (a) (i) if not drawn in this part

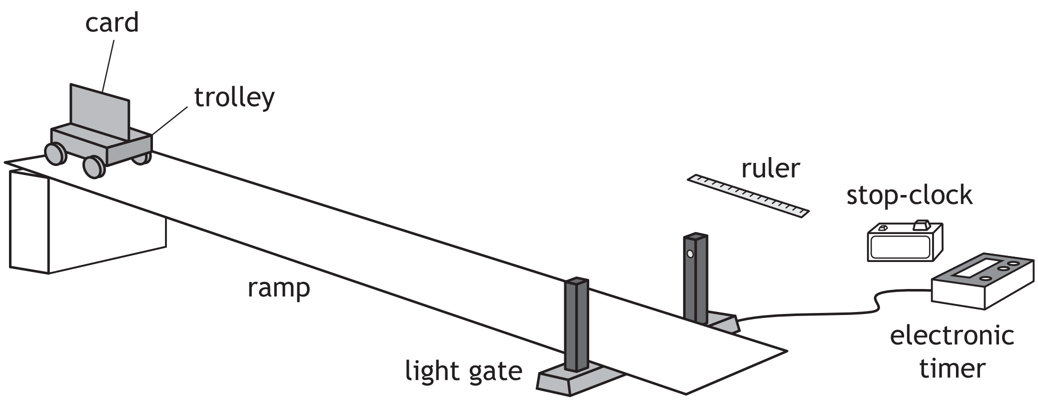
Question			Answer	Max Mark	Additional Guidance
		(iii)	$F = ma$ (1) $10 \times 10^3 = 5 \cdot 0 \times 10^6 \times a$ (1) $a = 2 \cdot 0 \times 10^{-3}$ m s^{-2} (1)	**3**	or consistent with (a) (i)
	(b)		buoyancy force/upthrust/force of water on ship/flotation force (1)  weight/force of gravity (1) (These) forces are balanced (1)	**3**	Independent marks Must describe forces on ship (i.e. not ‘ship pushes down on water’) Allow a clear description without a diagram but must indicate direction of force(s) eg weight/force of gravity acts down on ship (1) buoyancy force/upthrust/force of water on ship acts up (1) Do not accept: ‘gravity’ alone ‘buoyancy’ alone ‘upward force’ alone Ignore horizontal forces Accept: An explicit statement that ‘forces are equal and opposite’

8. A student is investigating the motion of a trolley down a ramp.

MARKS | DO NOT WRITE IN THIS MARGIN

(a) The student uses the apparatus shown to carry out an experiment to determine the acceleration of a trolley as it rolls down a ramp.

The trolley is released from rest at the top of the ramp.



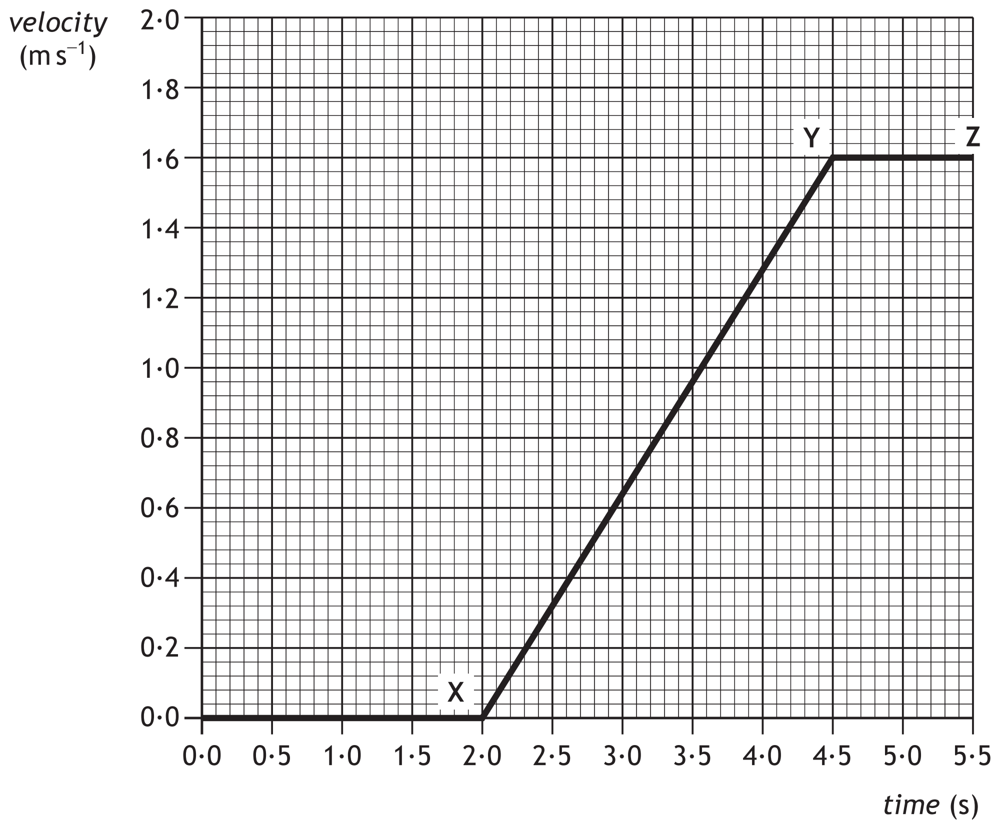
(i) State the measurements the student must make to calculate the acceleration of the trolley. **3**

(ii) Suggest one reason why the acceleration calculated from these measurements might not be accurate. **1**

MARKS DO NOT WRITE IN THIS MARGIN

8. (continued)

(b) In a second experiment, the student uses a motion sensor and computer to produce the following velocity-time graph for the trolley



Calculate the acceleration of this trolley between X and Y. **3**

Space for working and answer

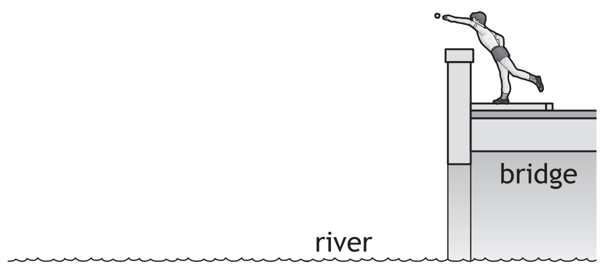
[Turn over

* X 7 5 7 7 5 0 1 2 1 *

Question			Answer	Max Mark	Additional Guidance
8.	(a)	(i)	• length/width of card (1) • time taken for card to pass (through) the light gate (1) • time taken (for trolley to travel from starting position) to light gate (1)	**3**	Independent marks Accept: • 'length of trolley' – the card and trolley have the same length • 'time for trolley to pass (through) light gate' Do not accept: • 'time from electronic timer' alone • 'time from stop-clock' alone • 'time from light gate' • 'time for trolley to go down ramp' • 'time for trolley to cut beam' – it is the card that cuts the beam Ignore additional information
		(ii)	reaction time (can cause error with the stop clock reading) **OR** card may not have passed straight through light gate **OR** Length/width of card not measured properly (eg ruler not straight along card) OR other suitable reason	**1**	Do not accept: • 'trolley might have been pushed' • 'human error' alone • 'experiment not repeated' If more than one reason stated apply the +/- rule (see page three)
	(b)		$a = \frac{v-u}{t}$ (1) $= \frac{1 \cdot 6 - 0}{2 \cdot 5}$ (1) $= 0 \cdot 64\ \text{ms}^{-2}$ (1)	**3**	Accept: $a = \frac{\Delta v}{t}$ Do not accept: $a = \frac{v}{t}$ Accept $0{\cdot}6\ \text{m s}^{-2}$

MARKS | DO NOT WRITE IN THIS MARGIN

9. A child throws a stone horizontally from a bridge into a river.



(a) On the above diagram sketch the path taken by the stone between leaving the child's hand and hitting the water. **1**

(b) The stone reaches the water 0·80 s after it was released.

(i) Calculate the vertical velocity of the stone as it reaches the water.

The effects of air resistance can be ignored. **3**

Space for working and answer

(ii) Determine the height above the water at which the stone was released. **4**

Space for working and answer

(c) The child now drops a similar stone vertically from the same height into the river.

State how the time taken for this stone to reach the water compares with the time taken for the stone in (b). **1**

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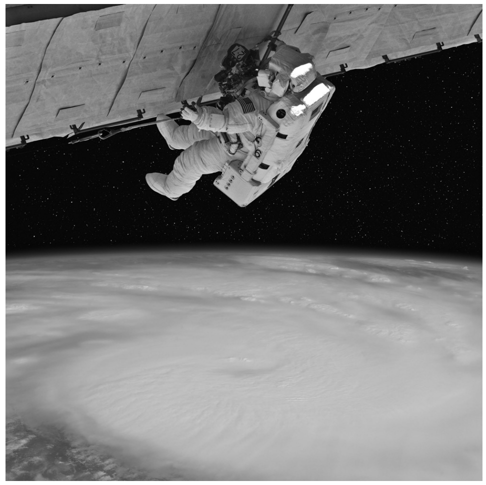
Question			Answer	Max Mark	Additional Guidance
9.	(a)	(i)	suitable curved path (1)	**1**	Do not accept an indication of stone rising
	(b)	(i)	$a = \frac{v-u}{t}$ (1) $9 \cdot 8 = \frac{v-0}{0 \cdot 80}$ (1) $v = 7 \cdot 8 \text{ ms}^{-1}$ (1)	**3**	Accept: $a = \frac{\Delta v}{t}$ $v = u + at$ Do not accept a response starting with: $a = \frac{v}{t}$ OR $v = at$ Accept: 8 m s^{-1} $7{\cdot}8 \text{ m s}^{-1}$ $7{\cdot}84 \text{ m s}^{-1}$

Question			Answer	Max Mark	Additional Guidance
		(ii)	$\bar{v} = 3{\cdot}9\ \text{m s}^{-1}$ (1) $d = \bar{v}\,t$ (1) $= 3{\cdot}9 \times 0{\cdot}80$ (1) $= 3{\cdot}1\ \text{m}$ (1)	**4**	Accept $d=vt$ without a bar over the v. Accept $d=st$ only if it is made clear, by a suitable substitution, that s is a speed. Where no formula is stated, an incorrect substitution cannot imply a correct formula. **Alternative method 1:** $E_k = E_p$ (1) $\frac{1}{2}mv^2 = mgh$ (1) $\frac{1}{2} \times m \times 7{\cdot}8^2 = m \times 9{\cdot}8 \times h$ (1) $h = 3{\cdot}1\ \text{m}$ (1) Allow mass to be cancelled or a value substituted **Alternative method 2:** height = area under (velocity-time) graph (1) velocity-time graph showing acceleration drawn (1) substitutions correct (1) final answer correct (1) For this method the formula and/or graph can be implied by a correct substitution.
	(c)		(it will take the) same (time)	**1**	Allow: 'unchanged' 'equal' Ignore additional information.

MARKS DO NOT WRITE IN THIS MARGIN

10. Space exploration involves placing astronauts in difficult environments. Despite this, many people believe the benefits of space exploration outweigh the risks.



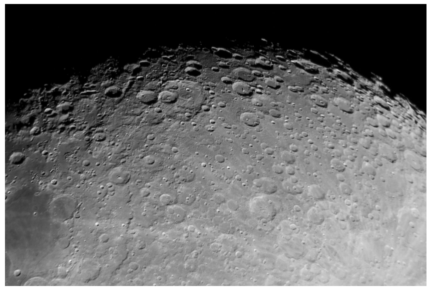
Using your knowledge of physics, comment on the benefits and/or risks of space exploration. **3**

[Turn over

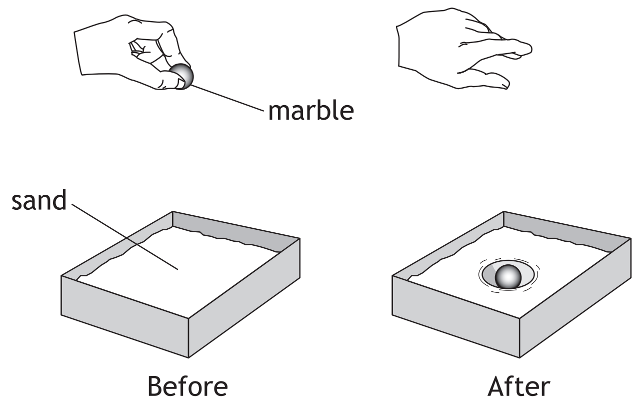
Back to Table

MARKS | DO NOT WRITE IN THIS MARGIN

11. Craters on the Moon are caused by meteors striking its surface.



A student investigates how a crater is formed by dropping a marble into a tray of sand.



(a) The marble has a mass of 0·040 kg.

(i) Calculate the loss in potential energy of the marble when it is dropped from a height of 0·50 m. **3**

Space for working and answer

(ii) Describe the energy change that takes place as the marble hits the sand. **1**

[Turn over

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Back to Table

11. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

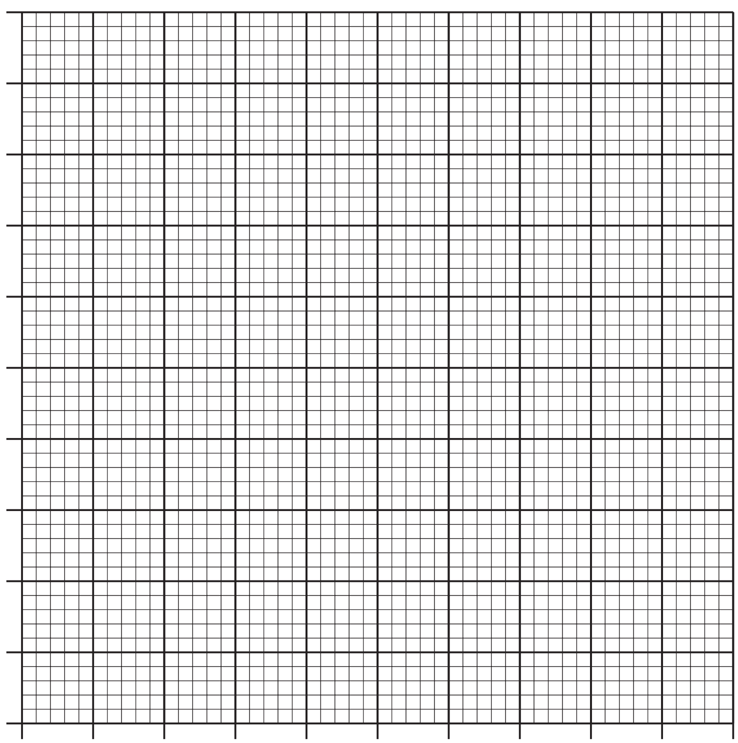
(b) The student drops the marble from different heights and measures the diameter of each crater that is formed.

The table shows the student's results.

height (m)	*diameter* (m)
0·05	0·030
0·10	0·044
0·15	0·053
0·35	0·074
0·40	0·076
0·45	0·076

(i) Using the graph paper below, draw a graph of these results. **3**

(Additional graph paper, if required, can be found on *Page twenty-eight*)



11. (b) (continued)

(ii) Use your graph to predict the diameter of the crater that is formed when the marble is dropped from a height of 0·25 m. **1**

(iii) Suggest two improvements that the student could make to this investigation. **2**

(c) (i) Suggest another variable, which could be investigated, that may affect the diameter of a crater. **1**

(ii) Describe experimental work that could be carried out to investigate how this variable affects the diameter of a crater. **2**

[END OF QUESTION PAPER]

Question				Max Mark	Additional Guidance
11.	(a)	(i)	$E_P = mgh$ (1) $E_P = 0{\cdot}040 \times 9{\cdot}8 \times 0{\cdot}50$ (1) $E_P = 0{\cdot}20$ J (1)	3	Accept: 0·2 J 0·20 J 0·196 J
		(ii)	kinetic (energy) to heat (and sound) OR kinetic (energy) of the marble to kinetic (energy) of the sand.	1	Accept: E_k to E_h Do not accept: 'kinetic to sound' alone
	(b)	(i)	suitable scales, labels and units (1) all points plotted accurately to ± half a division (1) best fit <u>curve</u> (1)	3	A non-linear scale on either axis prevents access to any marks. (0) For a suitable scale: The diameter scale between 0·03 m and 0·08 m must take up at least five major divisions of the graph paper The height scale between 0·05 m and 0·45 m must take up at least five major divisions of the graph paper. A bar chart can obtain a MAX of (1) - for scales, labels and units Allow broken axes from origin (with or without symbol), but scale must be linear across data range. Axes can be swapped Ignore any extrapolation Independent marks

Question			Answer	Max Mark	Additional Guidance
		(ii)	Consistent with best fit curve from (b)(i).	1	Or consistent with best fit line or dot-to-dot line. Unit required ± half a division tolerance If candidate has not shown a curve or line in (b) (i) this mark cannot be accessed.
		(iii)	Any two from: • Repeat (and average) • Take (more) readings in the 0·15 (m) to 0·35 (m) drop height range • Increase the height range • level sand between drops • or other suitable improvement (1) each	2	If more than two improvements stated apply the +/- rule (see page three) Accept 'take more readings' as an implication of repetition.
	(c)	(i)	suitable variable eg • mass/weight of marble • angle of impact • type of sand • diameter of marble • radius of marble • density of marble • volume of marble • speed of marble • time of drop	1	Do not accept: 'size of marble' alone 'time' alone 'amount of…' These are insufficient rather than incorrect responses. If more than one variable stated apply the +/- rule (see page three)
		(ii)	How independent variable can be measured/changed (1) State at least one other variable to be controlled (1)	2	Consistent with (c) (i) Independent marks Accept: 'drop from same heights as before' as an implication of control of height

[END OF MARKING INSTRUCTIONS]

Back to Table

N5 National Qualifications 2016

X757/75/02

Physics
Section 1 — Questions

TUESDAY, 24 MAY

1:00 PM – 3:00 PM

Instructions for the completion of Section 1 are given on *Page 02* of your question and answer booklet X757/75/01.

Record your answers on the answer grid on *Page 03* of your question and answer booklet

Reference may be made to the Data Sheet on *Page 02* of this booklet and to the Relationships Sheet X757/75/11.

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

X757502

A/PB

Back to Table

DATA SHEET

Speed of light in materials

Material	*Speed* in m s^{-1}
Air	$3·0 \times 10^8$
Carbon dioxide	$3·0 \times 10^8$
Diamond	$1·2 \times 10^8$
Glass	$2·0 \times 10^8$
Glycerol	$2·1 \times 10^8$
Water	$2·3 \times 10^8$

Gravitational field strengths

	Gravitational field strength on the surface in N kg^{-1}
Earth	9·8
Jupiter	23
Mars	3·7
Mercury	3·7
Moon	1·6
Neptune	11
Saturn	9·0
Sun	270
Uranus	8·7
Venus	8·9

Specific latent heat of fusion of materials

Material	*Specific latent heat of fusion* in J kg^{-1}
Alcohol	$0·99 \times 10^5$
Aluminium	$3·95 \times 10^5$
Carbon Dioxide	$1·80 \times 10^5$
Copper	$2·05 \times 10^5$
Iron	$2·67 \times 10^5$
Lead	$0·25 \times 10^5$
Water	$3·34 \times 10^5$

Specific latent heat of vaporisation of materials

Material	*Specific latent heat of vaporisation* in J kg^{-1}
Alcohol	$11·2 \times 10^5$
Carbon Dioxide	$3·77 \times 10^5$
Glycerol	$8·30 \times 10^5$
Turpentine	$2·90 \times 10^5$
Water	$22·6 \times 10^5$

Speed of sound in materials

Material	*Speed* in m s^{-1}
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Specific heat capacity of materials

Material	*Specific heat capacity* in J kg^{-1} °C^{-1}
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Ice	2100
Iron	480
Lead	128
Oil	2130
Water	4180

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
Iron	1537	2737

Radiation weighting factors

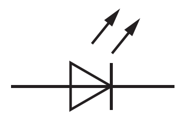
Type of radiation	*Radiation weighting factor*
alpha	20
beta	1
fast neutrons	10
gamma	1
slow neutrons	3
X-rays	1

Back to Table

SECTION 1

Attempt ALL questions

1. The symbol for an electronic component is shown.



This is the symbol for

A an LDR

B a transistor

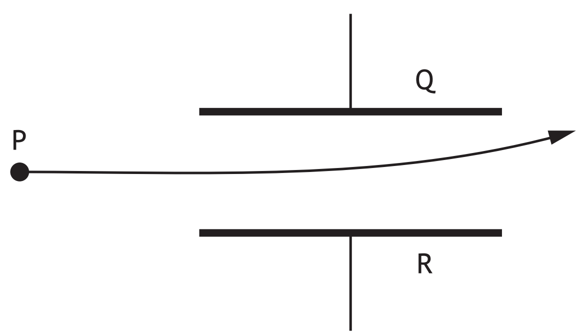
C an LED

D a photovoltaic cell

E a thermistor.

2. A uniform electric field exists between plates Q and R.

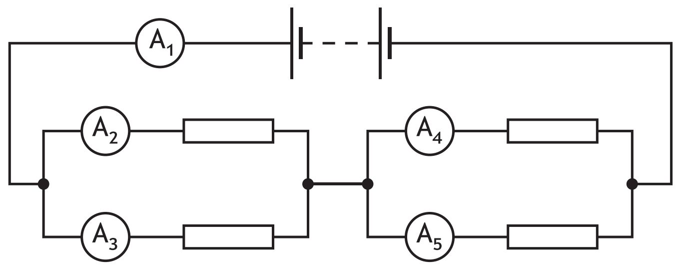
The diagram shows the path taken by a particle as it passes through the field.



Which row in the table identifies the charge on the particle, the charge on plate Q and the charge on plate R?

	Charge on particle	*Charge on plate Q*	*Charge on plate R*
A	negative	positive	negative
B	negative	negative	positive
C	no charge	negative	positive
D	no charge	positive	negative
E	positive	positive	negative

3. A circuit is set up as shown.



The reading on ammeter A_1 is 5·0 A.

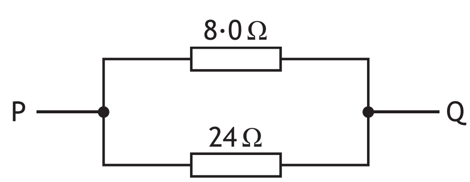
The reading on ammeter A_2 is 2·0 A.

The reading on ammeter A_4 is 1·0 A.

Which row in the table shows the reading on ammeters A_3 and A_5?

	Reading on ammeter A_3 (A)	*Reading on ammeter A_5* (A)
A	2·0	1·0
B	3·0	1·0
C	2·0	4·0
D	3·0	4·0
E	5·0	5·0

4. Two resistors are connected as shown.



The total resistance between P and Q is

A 0·17 Ω

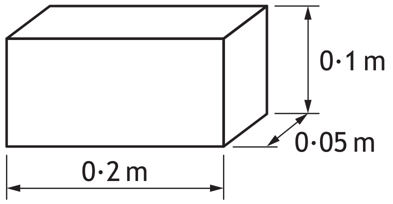
B 3·0 Ω

C 6·0 Ω

D 16 Ω

E 32 Ω.

5. A block has the dimensions shown.



The block is placed so that one of the surfaces is in contact with a smooth table top.

The weight of the block is 4·90 N.

The **minimum** pressure exerted by the block on the table top is

A 25 Pa

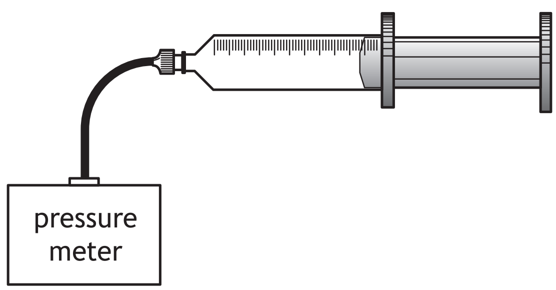
B 245 Pa

C 490 Pa

D 980 Pa

E 4900 Pa.

6. A syringe is connected to a pressure meter as shown.



The syringe contains a fixed mass of air of volume 150 mm^3.

The reading on the pressure meter is 120 kPa.

The volume of air inside the syringe is now changed to 100 mm^3.

The temperature of the air in the syringe remains constant.

The reading on the pressure meter is now

A 80 kPa

B 125 kPa

C 180 kPa

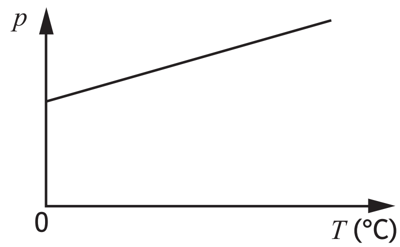
D 80 000 kPa

E 180 000 kPa.

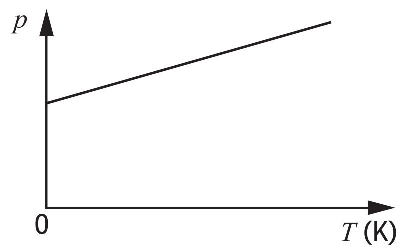
7. A sample of an ideal gas is enclosed in a sealed container.

Which graph shows how the pressure p of the gas varies with the temperature T of the gas?

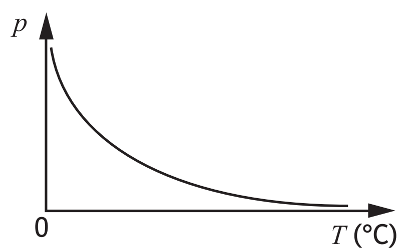
A



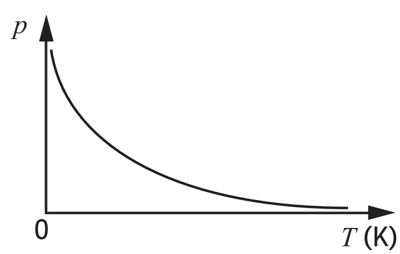
B



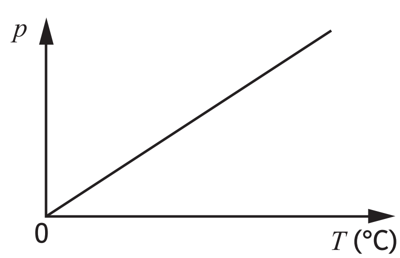
C



D



E



8. A student makes the following statements about waves.

I Waves transfer energy.

II A wave with a short wavelength diffracts more than a wave with a long wavelength.

III The amplitude of a wave depends on its wavelength.

Which of these statements is/are correct?

A I only

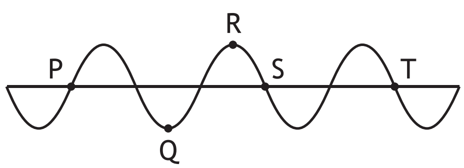
B II only

C III only

D I and II only

E I and III only

9. The diagram represents a wave.



The wavelength of the wave is the horizontal distance between points

A P and Q

B P and S

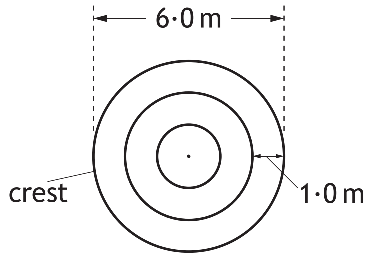
C Q and R

D R and S

E S and T.

[Turn over

10. The diagram represents the position of the crests of waves 3 seconds after a stone is thrown into a pool of still water.



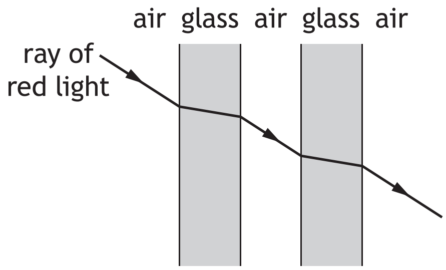
Which row in the table shows the speed and the frequency of the waves?

	Speed ($m\,s^{-1}$)	*Frequency* (Hz)
A	0·33	3
B	0·33	1
C	1·0	1
D	1·0	3
E	1·0	4

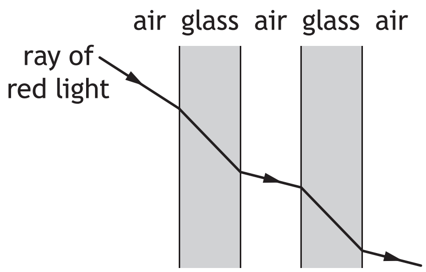
11. A ray of red light passes through a double glazed window.

Which diagram shows the path of the ray as it passes through the window?

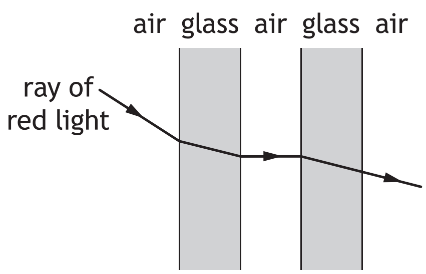
A



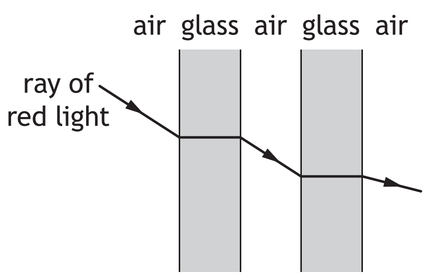
B



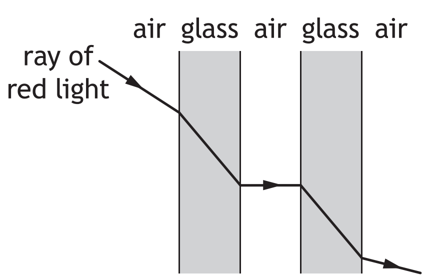
C



D



E



[Turn over

12. Which row in the table shows how the mass and charge of an alpha particle compares to the mass and charge of a beta particle?

	Mass of an alpha particle compared to mass of a beta particle	*Charge on an alpha particle compared to charge on a beta particle*
A	larger	same
B	larger	opposite
C	same	same
D	smaller	opposite
E	smaller	same

13. During ionisation an atom becomes a positive ion.

Which of the following has been removed from the atom?

A An alpha particle

B An electron

C A gamma ray

D A neutron

E A proton

14. Which of the following is a vector quantity?

A Mass

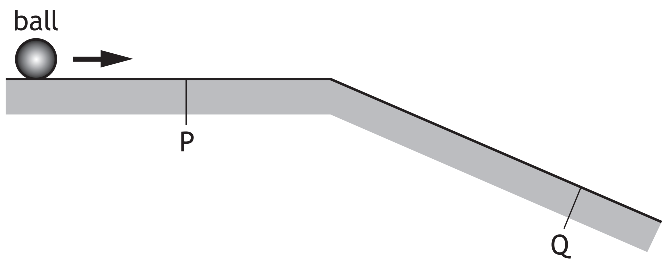
B Time

C Speed

D Kinetic energy

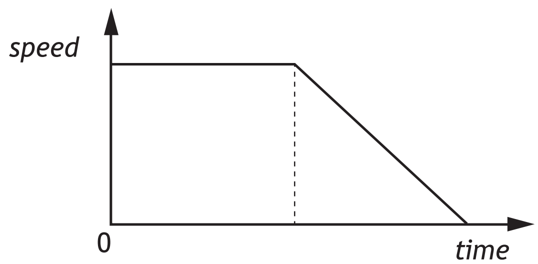
E Acceleration

15. A ball moves along a horizontal frictionless surface and down a slope as shown.

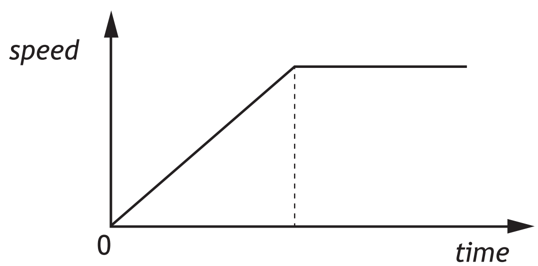


Which of the following graphs shows how the speed of the ball varies with time as it travels from P to Q?

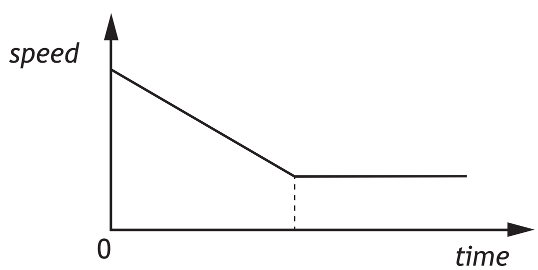
A



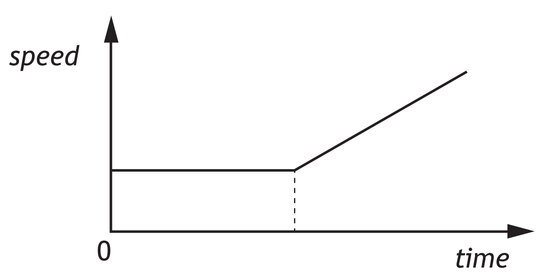
B



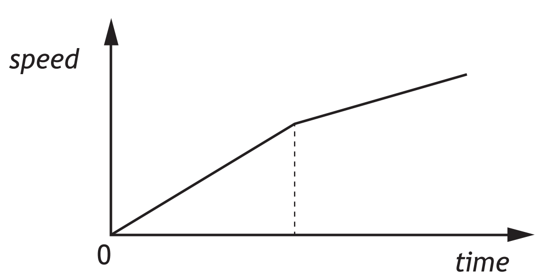
C



D



E



16. A cyclist is travelling at $10\,m\,s^{-1}$ along a level road.

The cyclist applies the brakes and comes to rest in a time of 5 s.

The combined mass of the cycle and cyclist is 80 kg.

The maximum energy converted to heat by the brakes is

A 160 J

B 400 J

C 800 J

D 4000 J

E 8000 J.

17. A rocket is taking off from the surface of the Earth. The rocket engines exert a force on the exhaust gases.

Which of the following is the reaction to this force?

A The force of the Earth on the exhaust gases.

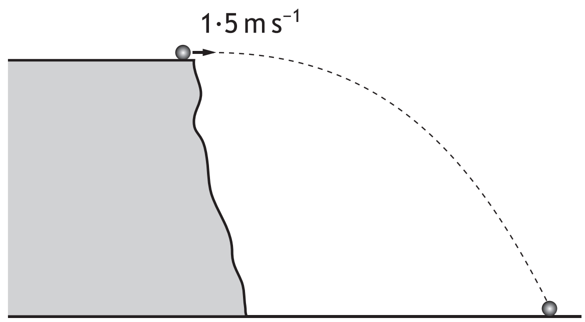
B The force of the Earth on the rocket engines.

C The force of the rocket engines on the Earth.

D The force of the exhaust gases on the Earth.

E The force of the exhaust gases on the rocket engines.

18. A ball is projected horizontally with a velocity of $1{\cdot}5\,m\,s^{-1}$ from a cliff as shown.



The ball hits the ground $1{\cdot}2\,s$ after it leaves the cliff.

The effects of air resistance are negligible.

Which row in the table shows the horizontal velocity and vertical velocity of the ball just before it hits the ground?

	Horizontal velocity ($m\,s^{-1}$)	*Vertical velocity* ($m\,s^{-1}$)
A	12	12
B	12	1·5
C	1·5	12
D	1·5	13
E	0	12

19. The minimum amount of energy required to change 0·5 kg of water at its boiling point into steam at the same temperature is

A $2{\cdot}09 \times 10^3$ J

B $1{\cdot}67 \times 10^5$ J

C $3{\cdot}34 \times 10^5$ J

D $1{\cdot}13 \times 10^6$ J

E $2{\cdot}26 \times 10^6$ J.

[Turn over for next question

20. A student makes the following statements about the Universe.

I The Big Bang Theory is a theory about the origin of the Universe.

II The Universe is approximately 14 million years old.

III The Universe is expanding.

Which of these statements is/are correct?

A I only

B II only

C I and II only

D I and III only

E I, II and III.

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET]

Detailed Marking Instructions for each question

Section 1

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

Back to Table

FOR OFFICIAL USE

N5

National Qualifications 2016

Mark

X757/75/01

Physics
Section 1 — Answer Grid and Section 2

TUESDAY, 24 MAY

1:00 PM – 3:00 PM

* X 7 5 7 7 5 0 1 *

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 — 110

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

SECTION 2 — 90 marks
Attempt ALL questions.

Reference may be made to the Data Sheet on *Page 02* of the question paper X757/75/02 and to the Relationships Sheet X757/75/11.

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.

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

MARKS | DO NOT WRITE IN THIS MARGIN

SECTION 2 — 90 marks

Attempt ALL questions

1. Electrical storms occur throughout the world.

During one lightning strike 24 C of charge is transferred to the ground in 0·0012 s.

(a) Calculate the average current during the lightning strike. **3**

Space for working and answer

(b) The charge on an electron is $-1{\cdot}6 \times 10^{-19}$ C.

Determine the number of electrons transferred during the lightning strike. **1**

Space for working and answer

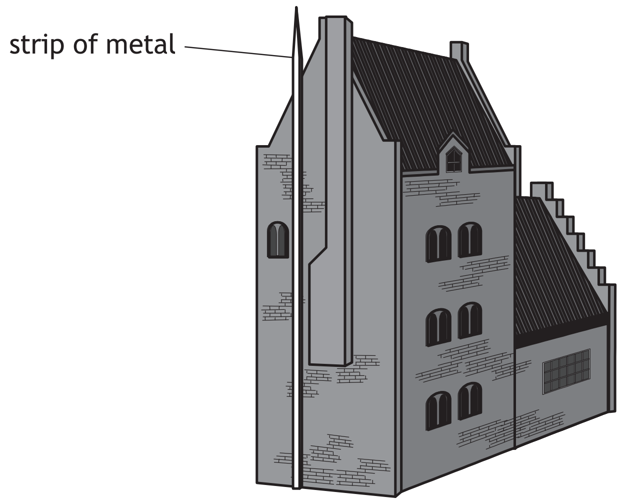
* X 7 5 7 7 5 0 1 0 6 *

Back to Table

MARKS DO NOT WRITE IN THIS MARGIN

1. (continued)

(c) Many tall buildings have a thick strip of metal attached to the side of the building.



This strip is used to protect the building from damage during electrical storms.

Explain how this strip protects the building from damage. **2**

X757750107

Back to Table

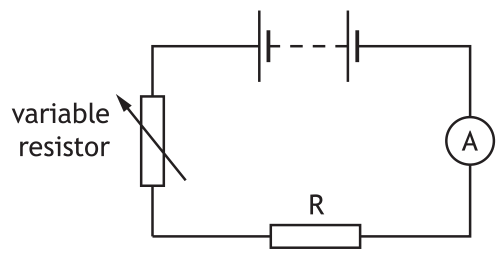
[Turn over

Section 2

Question			Answer	Max Mark	Additional Guidance
1.	(a)		$Q = It$ (1) $24 = I \times 0{\cdot}0012$ (1) $I = 20\,000$ A (1)	**3**	
	(b)		$24 \div 1{\cdot}6 \times 10^{-19}$ $= 1{\cdot}5 \times 10^{20}$ (electrons) (1)	**1**	Ignore negative values in substitution and/or final answer.
	(c)		(metal strip) is a conductor (1) (More) current will pass through (the strip than building) (1)	**2**	Accept: 'it conducts (electricity)' 'it has less resistance (than the building)' Accept: 'charge/electrons will pass through' 'less/no current will pass through the building' Do not accept: 'lightning/electricity will pass through'

MARKS | DO NOT WRITE IN THIS MARGIN

2. A student investigates the resistance of a resistor using the circuit shown.



(a) Complete the circuit diagram to show where a voltmeter must be connected to measure the voltage across resistor R. **1**

(An additional diagram, if required, can be found on Page 33.)

(b) Describe how the student obtains a range of values of voltage and current. **1**

X757750108

MARKS | DO NOT WRITE IN THIS MARGIN

2. (continued)

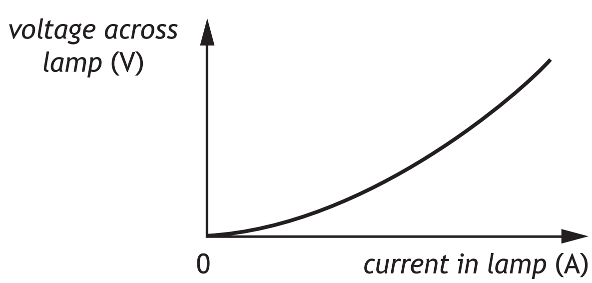
(c) The results of the student's investigation are shown.

Voltage across resistor R (V)	*Current in resistor R* (A)
1·0	0·20
2·5	0·50
3·2	0·64
6·2	1·24

Use **all** these results to determine the resistance of resistor R. **4**

Space for working and answer

(d) The student now replaces resistor R with a filament lamp and repeats the investigation. A sketch graph of the student's results is shown.



State a conclusion that can be made about the resistance of the filament lamp. **1**

2.	(a)		Voltmeter across resistor R (1)	**1**	Correct symbol must be used.
	(b)		increase/decrease/vary/change the <u>resistance</u> of the <u>variable resistor</u>	**1**	Accept: 'change the number of cells/batteries' 'use batter<u>ies</u> with different <u>voltages</u>' Do not accept: 'change the voltage of the battery'

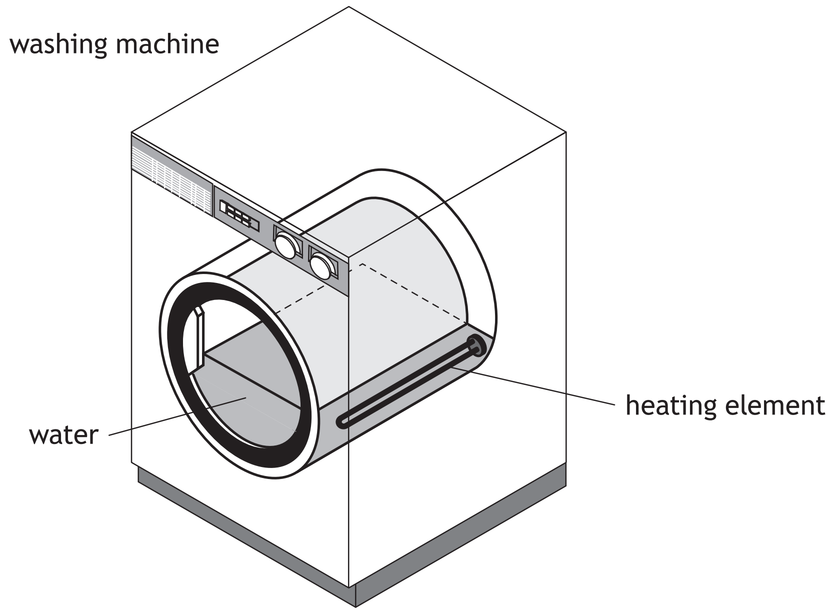
Question			Answer	Max Mark	Additional Guidance
	(c)		**Numerical method:** Ohm's Law stated (1) **All** substitutions shown (2) 5 Ω (1) $V = IR$ $1 = 0 \cdot 2 \times R$ $R = 5\ (\Omega)$ $V = IR$ $2 \cdot 5 = 0 \cdot 5 \times R$ $R = 5\ (\Omega)$ $V = IR$ $3 \cdot 2 = 0 \cdot 64 \times R$ $R = 5\ (\Omega)$ $V = IR$ $6 \cdot 2 = 1 \cdot 24 \times R$ $R = 5\ (\Omega)$ (resistance of R = 5 Ω) **Graphical method:** Suitable scales and labels (1) All points plotted accurately to ±half a division (2) Line drawn and gradient calculated to be 5 Ω (1)	**4**	Ohm's Law may appear at any stage in the candidate's response To get full marks all data must be used. If only 2 or 3 correct substitutions shown (1) mark can be awarded for substitution. (ie (3) marks MAX). If no substitution or only 1 correct substitution is shown candidate cannot be awarded the substitution marks. (ie (2) marks MAX). If a candidate totals or averages the voltages and currents then (1) mark MAX for Ohm's Law. The resistance of R does not need to be stated separately. However, all calculated values must arrive at 5 Ω by correct use of Ohm's Law to gain the final mark. Unit must be shown at least once to be awarded final mark. Scale must be linear across data range. If only 2 or 3 points plotted (1) mark can be awarded for points (ie (3) marks MAX). If only 1 point plotted candidate cannot be awarded the plotting marks. (ie (2) marks MAX).
	(d)		(Resistance is) changing/not constant/increasing	**1**	Do not accept: 'resistance is decreasing'

Back to Table

MARKS | DO NOT WRITE IN THIS MARGIN

3. A washing machine fills with water at a temperature of 15·0 °C.

The water is heated by a heating element.



(a) The mass of the water in the washing machine is 6·00 kg.

Show that the minimum energy required to increase the temperature of the water from 15·0 °C to 40·0 °C is 627 000 J. **2**

Space for working and answer

X757750110

Back to Table

MARKS DO NOT WRITE IN THIS MARGIN

3. (continued)

(b) The heating element has a power rating of 1800 W.

(i) Calculate the time taken for the heating element to supply the energy calculated in (a). **3**

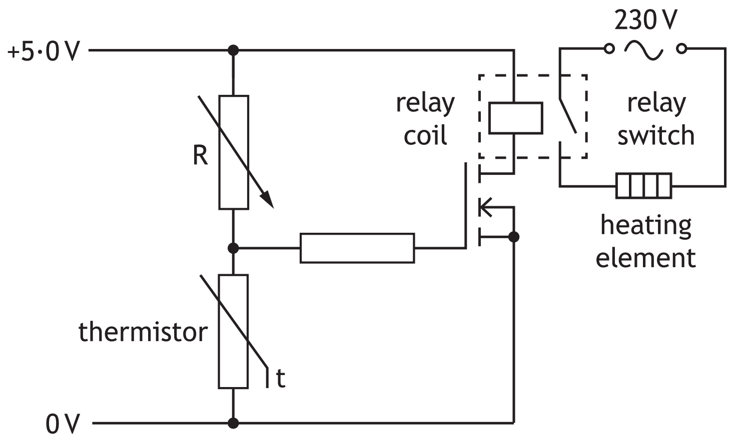
Space for working and answer

(ii) Explain why, in practice, it takes longer to heat the water from 15 °C to 40 °C than calculated in (b)(i). **1**

MARKS | DO NOT WRITE IN THIS MARGIN

3. (continued)

(c) The temperature of the water in the washing machine is monitored by a circuit containing a thermistor.



As the temperature of the water increases, the resistance of the thermistor decreases.

The heating element is switched off when the temperature of the water reaches 40 °C.

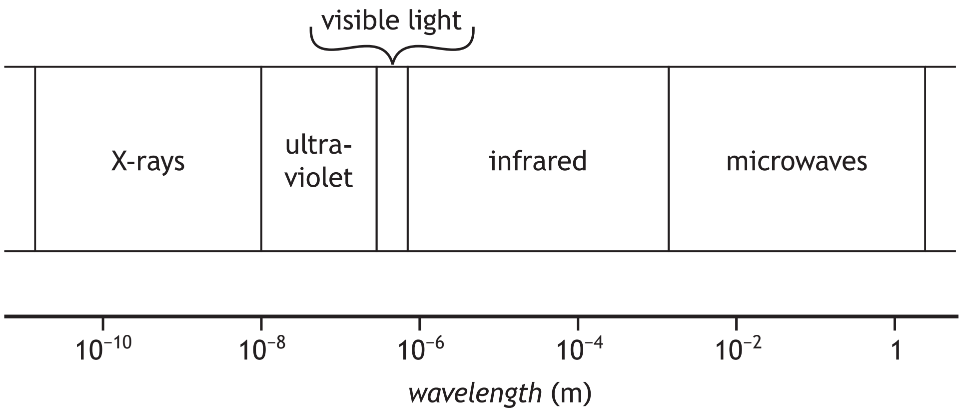
Explain how the circuit operates to **switch off** the heating element. **3**

Question			Answer	Max Mark	Additional Guidance
3.	(a)		** SHOW THAT ** Must start with the correct equation or (0) $E_h = cm\Delta T$ (1) $E_h = 4180 \times 6 \cdot 0 \times 25$ (1) $E_h = 627\,000$ J	2	Final answer of 627 000 J or its numerical equivalent, including unit, must be shown, otherwise a maximum of (1) can be awarded For alternative methods calculating c, m or ΔT there must be final statement to show that calculated value of c, m or ΔT is the same as the value stated in the question/data sheet to gain the second mark. eg $E_h = cm\Delta T$ (1) $627\,000 = 4180 \times m \times 25$ (1) $m = 6 \cdot 0$ kg i.e. same mass as stated in question If c substituted as 4·18 it must be clear that the energy calculated is then in kJ.
	(b)	(i)	$P = \frac{E}{t}$ (1) $1800 = \frac{627\,000}{t}$ (1) $t = 350$ s (1)	3	Accept: 300 s 350 s 348 s 348·3 s Do not accept: 'secs'
		(ii)	Heat (energy) is lost (from the water) to the washing machine/drum /surroundings/clothing **OR** Some of the energy is used to heat up the washing machine/element/drum/clothing	1	Do not accept: 'heat loss' alone - it must be clear where it is going

Question			Answer	Max Mark	Additional Guidance
	(c)		Voltage across thermistor decreases (1) MOSFET/transistor switches off/deactivates (1) Relay switches off/relay switch opens/relay deactivates (1)	**3**	(3) independent marks Do not accept 'voltage through thermistor decreases'. Ignore any stated values of switching voltage. Ignore reference to it being an npn transistor. As these are independent marks, ignore any extraneous information, even if incorrect.

MARKS | DO NOT WRITE IN THIS MARGIN

4. The diagram shows some parts of the electromagnetic spectrum in order of increasing wavelength.



(a) State a detector of infrared radiation. **1**

(b) State which radiation in the electromagnetic spectrum has a wavelength shorter than X-rays. **1**

(c) (i) An electromagnetic wave has a frequency of 1·2 GHz.

Show that the wavelength of this wave is 0·25 m. **2**

Space for working and answer

(ii) Identify the part of the spectrum that this wave belongs to. **1**

* X 7 5 7 7 5 0 1 1 3 *

Question			Answer	Max Mark	Additional Guidance
4.	(a)		(black bulb) thermometer, photodiode, phototransistor, thermistor, thermocouple, CCD, thermochromic film	**1**	Do not accept: Skin (Infrared/thermal imaging) camera Photographic film thermogram
	(b)		Gamma (radiation/rays)	**1**	
	(c)	(i)	** SHOW THAT ** Must start with the correct equation or (0) $v = f\lambda$ (1) $3 \cdot 0 \times 10^8 = 1 \cdot 2 \times 10^9 \times \lambda$ (1) $\lambda = 0 \cdot 25$ m	**2**	Final answer of 0·25 m or its numerical equivalent, including unit, must be shown, otherwise a maximum of (1) can be awarded. For alternative methods calculating v or f there must be final statement to show that calculated value of v or f is the same as the value stated in the question/data sheet to gain the second mark.
		(ii)	Microwave (radiation)	**1**	Accept: 'microwaves'

MARKS DO NOT WRITE IN THIS MARGIN

5. A Physics textbook contains the following statement.

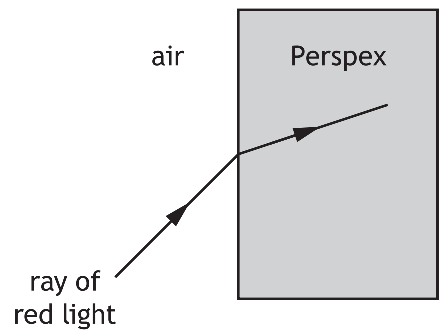
"Electromagnetic waves can be sent out like ripples on a pond."

Using your knowledge of physics, comment on the similarities and/or differences between electromagnetic waves and the ripples on a pond. **3**

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

MARKS | DO NOT WRITE IN THIS MARGIN

6. A student directs a ray of red light into a Perspex block to investigate refraction.



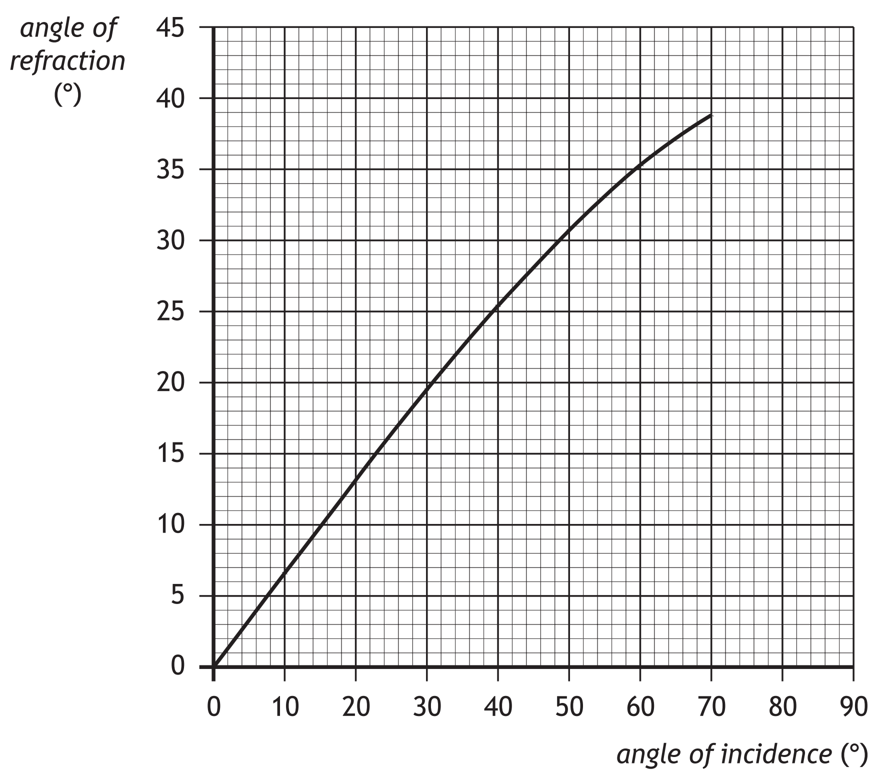
(a) On the diagram, draw and label:

(i) the normal; **1**

(ii) the angle of incidence *i* and the angle of refraction *r*. **1**

(An additional diagram, if required, can be found on *Page 33*)

(b) The student varies the angle of incidence and measures the corresponding angles of refraction. The results are plotted on a graph.



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MARKS DO NOT WRITE IN THIS MARGIN

6. (b) (continued)

(i) Determine the angle of refraction when the angle of incidence is 12°. **1**

(ii) Use the graph to predict the angle of refraction the student would obtain for an angle of incidence of 80°. **1**

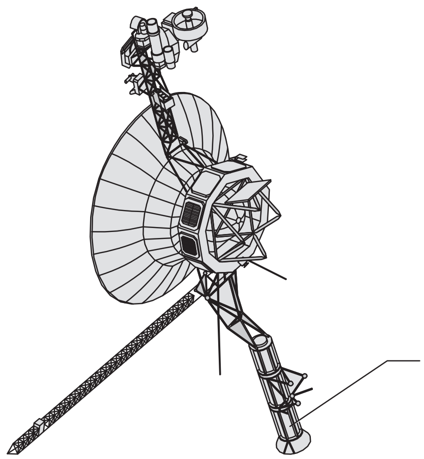
(c) Suggest why it would be good practice for the student to repeat the investigation a further three or four times. **1**

Question			Answer	Max Mark	Additional Guidance
6.	(a)	(i)	normal drawn <u>and labelled</u>	**1**	Must be ‘passably’ perpendicular and straight Does not need to be dashed Accept: ‘N’ or ‘n’ as label
		(ii)	Both angles indicated and labelled	**1**	Accept: i and r I and R θ_i and θ_r If normal has been incorrectly drawn, then this mark is still accessible, provided angles are indicated to the normal and labelled. Accept angles indicated either entering or leaving the Perspex block
	(b)	(i)	8°	**1**	Allow ±0·5° tolerance Unit must be included
		(ii)	Any single value between 40° and 42° inclusive.	**1**	Unit must be included
	(c)		Any one of: To obtain more reliable results Eliminate rogue results/outliers To allow an average/mean to be calculated More accurate	**1**	Do not accept: ‘more precise’ ‘better results’ ‘to make it a fair test’

Back to Table

MARKS | DO NOT WRITE IN THIS MARGIN

7. A spacecraft uses a radioisotope thermoelectric generator (RTG) as a power source.



The RTG transforms the heat released by the radioactive decay of plutonium–238 into electrical energy.

(a) In 15 minutes, $7{\cdot}92 \times 10^{18}$ nuclei of plutonium-238 decay.

Calculate the activity of the plutonium-238. **3**

Space for working and answer

(b) Each decay produces heat that is transformed into $4{\cdot}49 \times 10^{-14}$ J of electrical energy.

Determine the power output of the RTG. **2**

Space for working and answer

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Back to Table

MARKS DO NOT WRITE IN THIS MARGIN

7. (continued)

(c) Plutonium-238 emits alpha radiation.

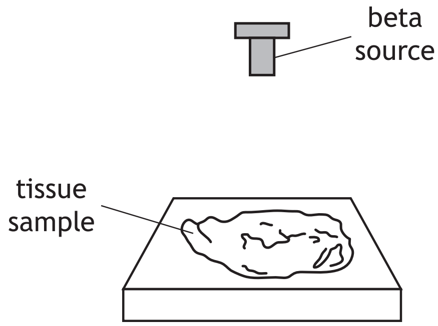
Explain why a source that emits alpha radiation requires less shielding than a source that emits gamma radiation. **1**

Question			Answer	Max Mark	Additional Guidance
7.	(a)		$A = \frac{N}{t}$ (1) $A = \frac{7 \cdot 92 \times 10^{18}}{900}$ (1) $A = 8 \cdot 8 \times 10^{15}$ Bq (1)	**3**	Accept: 9×10^{15} Bq **OR** $A = \frac{N}{t}$ (1) $A = \frac{7 \cdot 92 \times 10^{18}}{15}$ (1) $A = 5 \cdot 28 \times 10^{17}$ decays per min (1)
	(b)		$8 \cdot 8 \times 10^{15} \times 4 \cdot 49 \times 10^{-14}$ (1) $= 400$ W (1)	**2**	Or consistent with part (a) Accept: 400 W 395 W 395·1 W **Alternative method:** (not a standard three marker) ($P = \frac{E}{t}$) no mark for equation $P = \frac{7 \cdot 92 \times 10^{18} \times 4 \cdot 49 \times 10^{-14}}{900}$ (1) $P = 400$ W (1)
	(c)		Any one of: (Alpha is) more easily absorbed/stopped/blocked (Alpha) is absorbed by thinner materials/less dense materials. Gamma is absorbed by thicker materials/more dense materials. (Alpha) is less penetrating (than gamma). Gamma is more penetrating (than alpha)	**1**	Must be a comparison. Do not accept: 'Alpha is absorbed by a sheet of paper' alone 'Gamma is absorbed by lead' alone Do not accept comparison of range in air alone

MARKS DO NOT WRITE IN THIS MARGIN

8. During medical testing a beta source is used to irradiate a sample of tissue of mass 0·50 kg from a distance of 0·10 m.

The sample absorbs $9{\cdot}6 \times 10^{-5}$ J of energy from the beta source.



(a) (i) Calculate the absorbed dose received by the sample. **3**

Space for working and answer

(ii) Calculate the equivalent dose received by the sample. **3**

Space for working and answer

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MARKS DO NOT WRITE IN THIS MARGIN

8. (continued)

(b) The beta source used during testing has a half-life of 36 hours.

The initial activity of the beta source is 12 kBq.

Determine the activity of the source 144 hours later. **3**

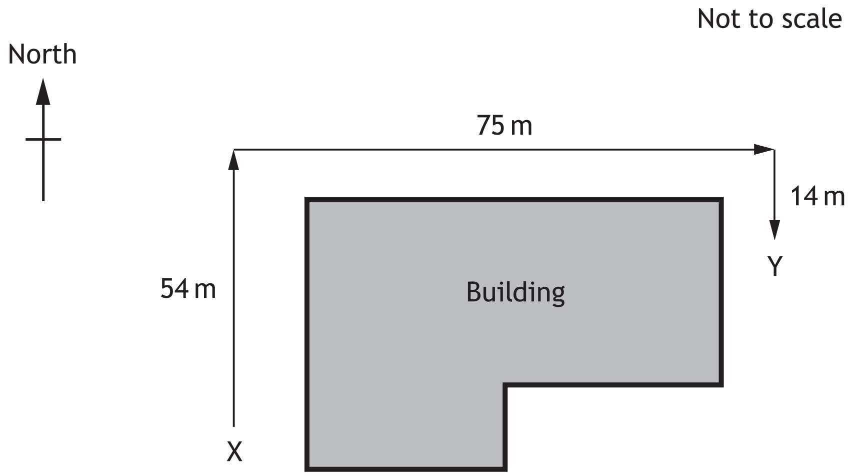
Space for working and answer

* X 7 5 7 7 5 0 1 2 1 *

Question			Answer	Max Mark	Additional Guidance
8.	(a)	(i)	$D=\frac{E}{m}$ (1) $D=\frac{9\cdot6\times10^{-5}}{0\cdot5}$ (1) $D=1\cdot9\times10^{-4}$ Gy (1)	**3**	Accept: 2×10^{-4} Gy $1\cdot9\times10^{-4}$ Gy $1\cdot92\times10^{-4}$ Gy $1\cdot920\times10^{-4}$ Gy Accept: J kg^{-1}
		(ii)	$H=Dw_R$ (1) $H=1\cdot9\times10^{-4}\times1$ (1) $H=1\cdot9\times10^{-4}$ Sv (1)	**3**	Accept answer consistent with that given in part (i) If incorrect radiation weighting factor selected then (1) MAX for correct equation
	(b)		No. of half-lives = $\frac{144}{36}$ = 4 (1) 12 → 6 → 3 → 1·5 → 0·75 mark for evidence of activity halving (1) Final Answer: 0·75 kBq (1)	**3**	Accept: 750 Bq Accept calculation using division by 2^4 eg $\left(A=\frac{A_0}{2^n}\right)$ $=\frac{12}{2^4}$ (1) +(1) $=0\cdot75$ kBq (1) substitution shows evidence of halving the activity (1) and 4 half-lives (1)

MARKS DO NOT WRITE IN THIS MARGIN

9. A student walks around a building from point X to point Y.



(a) By scale diagram, or otherwise, determine:

(i) the magnitude of the displacement of the student from point X to point Y; **2**

Space for working and answer

(ii) the direction of displacement of the student from point X to point Y. **2**

Space for working and answer

9. (continued)

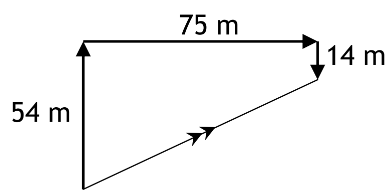
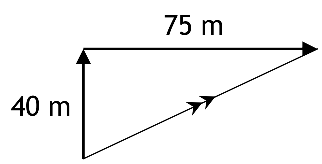
(b) The student takes 68 s to travel from point X to point Y.

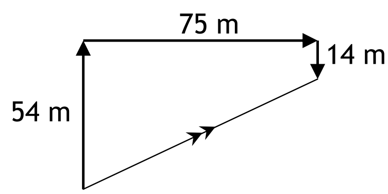
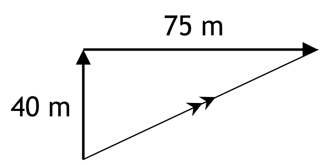
(i) Determine the average velocity of the student from point X to point Y. **3**

Space for working and answer

(ii) The student states that their average speed between point X and point Y is greater than the magnitude of their average velocity between point X and point Y.

Explain why the student is correct. **2**

Question			Answer	Max Mark	Additional Guidance
9.	(a)	(i)	**Using Pythagoras:** $\text{Resultant}^2 = 40^2 + 75^2$ (1) Resultant = 85 m (1) **Using scale diagram:**  **or**  Vectors to scale (1) Resultant = 85 m (1) (allow ±5 m tolerance)	**2**	Ignore any direction stated in this part. If clear arithmetic error shown in 54-14 = 40, then MAX (1) mark for substitution consistent with arithmetic error. No requirement for any arrows on diagram to calculate the magnitude of the displacement. Can obtain first mark for scale diagram method from suitable diagram in part (a)(ii) if not drawn in this part.

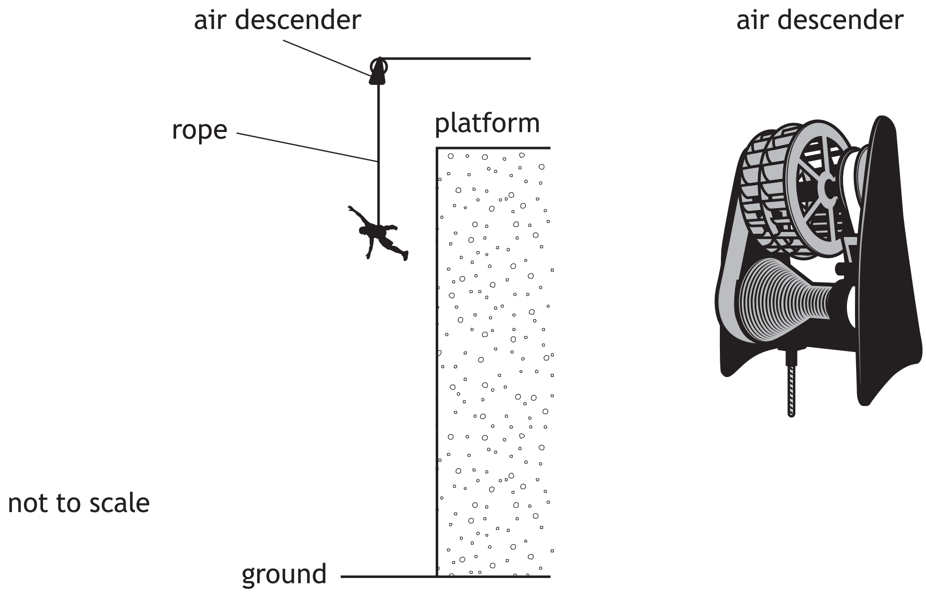
Question			Answer	Max Mark	Additional Guidance
		(ii)	**Using trigonometry:** $\tan\theta = \frac{75}{40}$ (1) $(\theta = 62°)$ direction = 062 (1) **Using scale diagram:**  **or**  Angles correct (1) direction = 062 (1) (allow $\pm 2°$ tolerance)	**2**	Or use of <u>resultant</u> value (and appropriate trigonometric function) consistent with (a)(i) Accept: 62° East of North 28° North of East Accept: 60° E of N 060 62° E of N 062 61·9° E of N 061·9 61·93° E of N 061·93 Ignore the degree symbol if direction is stated as a bearing Accept (for either method): 62° appropriately indicated on diagram (either written on directly or using clearly defined symbol), provided the resultant has an arrow indicating the correct direction (diagram may be in part (a)(i)).

Question			Answer	Max Mark	Additional Guidance
	(b)	(i)	$\bar{v} = \frac{s}{t}$ (1) $\bar{v} = \frac{85}{68}$ (1) $\bar{v} = 1 \cdot 3\,\text{m s}^{-1}$ at bearing 062 (1)	**3**	Or consistent with part (a) for magnitude and direction Must have direction for final mark. Accept: 1 m s $^{-1}$ 1·3 m s^{-1} 1·25 m s $^{-1}$ Accept: $v = \frac{s}{t}$ Accept: $\bar{v} = \frac{d}{t}$ or $v = \frac{d}{t}$, provided it is followed by a substitution of the value for displacement
		(ii)	distance is greater (than displacement) (1) same time (1)	**2**	Or by calculation of speed showing correct substitution for distance (1) and time (1) ie $v = \frac{d}{t}$ $v = \frac{143}{68}$ (1)+(1) $(v = 2 \cdot 1\text{ m s}^{-1})$

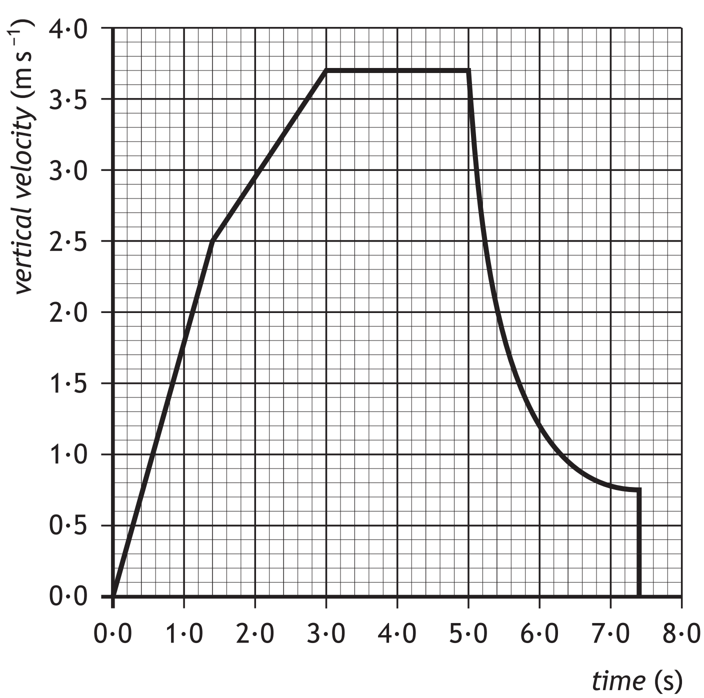
MARKS | DO NOT WRITE IN THIS MARGIN

10. An air descender is a machine that controls the rate at which a climber drops from a platform at the top of a climbing wall.

A climber, attached to the air descender by a rope, steps off the platform and drops towards the ground and lands safely.



The graph shows how the vertical velocity of the climber varies with time from the instant the climber leaves the platform until landing.



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MARKS | DO NOT WRITE IN THIS MARGIN

10. (continued)

(a) Calculate the acceleration of the climber during the first 1·4 s of the drop. **3**

Space for working and answer

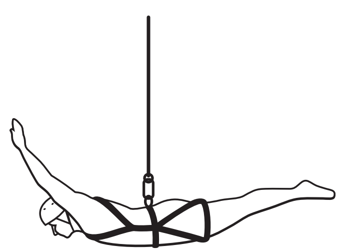
(b) Calculate the distance the climber drops during the first 3·0 s. **3**

Space for working and answer

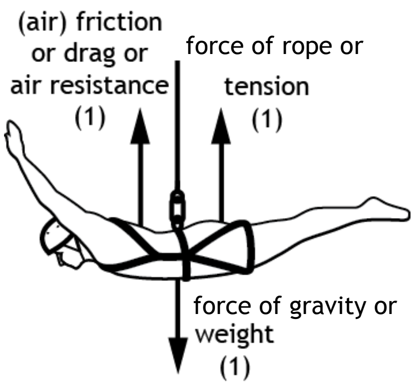
(c) During part of the drop the forces on the climber are balanced.

On the diagram below show all the forces acting vertically on the climber during this part of the drop.

You must name these forces **and** show their directions. **3**

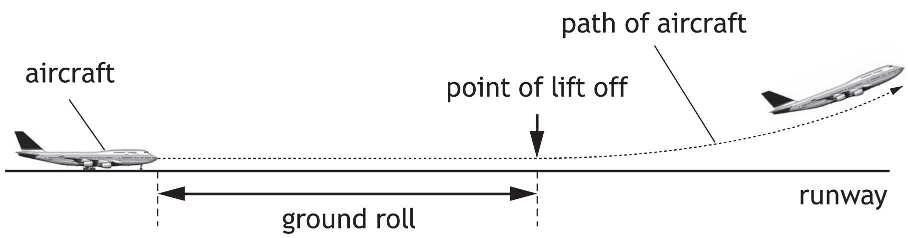


(An additional diagram, if required, can be found on *Page 33*)

Question			Answer	Max Mark	Additional Guidance
10.	(a)		$a=\frac{v-u}{t}$ (1) $a=\frac{2\cdot5-0}{1\cdot4}$ (1) $a=1\cdot8\ \text{m s}^{-2}$ (1)	**3**	Accept: $a=\frac{\Delta v}{t}$ $v=u+at$ Do not accept a response starting with: $a=\frac{v}{t}$ **OR** $v=at$ Accept: 2 m s^{-2} 1·8 m s^{-2} 1·79 m s^{-2} 1·786 m s^{-2}
	(b)		distance = area under graph (1) $=(½\times1\cdot4\times2\cdot5)+(1\cdot6\times2\cdot5)+(½\times1\cdot6\times1\cdot2)$ (1) $(=1\cdot75+4+0\cdot96)$ = 6·71 m (1)	**3**	If incorrect substitution then MAX (1) for (implied) equation. Any attempt to use $s=\bar{v}t$ (or $d=\bar{v}t$) applied to whole graph (eg 3·7 × 3·0) is wrong physics, award (0) marks. If $s=\bar{v}t$ (or $d=\bar{v}t$) is used for each section of the graph and the results added to give the correct total distance then full marks can be awarded. Ignore incorrect intermediate units eg m^2 Accept: 7 m 6·7 m 6·71 m 6·710 m
	(c)			**3**	(1) for each force correctly labelled with corresponding direction. Accept: 'pull of rope' 'gravitational pull' 'pull of gravity' Do not accept: 'pull/force of air descender' 'gravity' alone 'upward force' alone Ignore horizontal forces

MARKS | DO NOT WRITE IN THIS MARGIN

11. The length of runway required for aircraft to lift off the ground into the air is known as the ground roll.

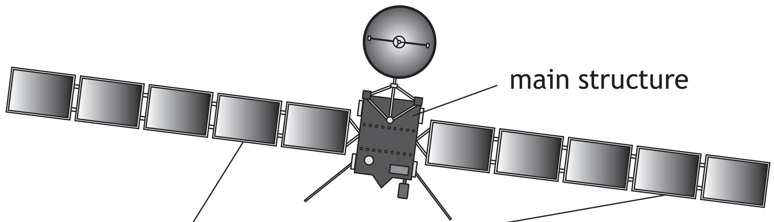


The ground roll of an aircraft varies for each take-off.

Use your knowledge of physics to comment on why the ground roll of an aircraft varies for each take-off. **3**

MARKS | DO NOT WRITE IN THIS MARGIN

12. On 12th November 2014, on a mission known as Rosetta, the European Space Agency successfully landed a probe on the surface of a comet.



The main structure of the Rosetta spacecraft consists of an orbiter, a lander and propellant.

Rosetta spacecraft data		
Launch mass	Orbiter Lander Propellant	$1{\cdot}23 \times 10^3$ kg $0{\cdot}10 \times 10^3$ kg $1{\cdot}67 \times 10^3$ kg
	Total	$3{\cdot}00 \times 10^3$ kg
Energy source	Solar array output	850 W at 3·4 AU 395 W at 5·25 AU
Trajectory control	24 Thrusters	10 N of force each

(a) Calculate the total weight of the spacecraft on Earth. **3**

Space for working and answer

(b) The solar arrays contain photovoltaic cells.

(i) State the energy change in a photovoltaic cell. **1**

(ii) Suggest why the solar arrays were designed so that they can rotate. **1**

12. (b) (continued)

(iii) Calculate the total energy output of the solar arrays when operating at 5·25 AU for 2 hours. **3**

Space for working and answer

(c) At a point on its journey between Earth and the comet, the spacecraft was travelling at a constant velocity.

(i) The spacecraft switched on four of its thrusters to accelerate it in the direction of travel.

The four thrusters exerted a force on the spacecraft in the same direction.

Determine the total force produced by these thrusters. **1**

Space for working and answer

(ii) At this point, the spacecraft had used $1{\cdot}00 \times 10^3$ kg of propellant.

Calculate the acceleration of the spacecraft. **4**

Space for working and answer

Question			Answer	Max Mark	Additional Guidance
12.	(a)		$W = mg$ (1) $W = 3{\cdot}00 \times 10^3 \times 9{\cdot}8$ (1) $W = 2{\cdot}9 \times 10^4$ N (1)	**3**	Do not accept 10 or 9·81 for g Accept: 3×10^4 N $2{\cdot}9 \times 10^4$ N $2{\cdot}94 \times 10^4$ N $2{\cdot}940 \times 10^4$ N
	(b)	(i)	light (energy) → electrical (energy)	**1**	Accept: light → electric 'to' instead of arrow Do not accept: light → electricity solar → electrical light — electrical(no direction)
		(ii)	Maximise the light received (from the Sun) (or similar)	**1**	Accept: So that they always face the Sun (or similar)
		(iii)	$E = Pt$ (1) $E = 395 \times 2 \times 60 \times 60$ (1) $E = 2{\cdot}8 \times 10^6$ J (1)	**3**	Accept: 3×10^6 J $2{\cdot}8 \times 10^6$ J $2{\cdot}84 \times 10^6$ J $2{\cdot}844 \times 10^6$ J
	(c)	(i)	(4 × 10 =) 40 N (1)	**1**	Unit must be stated
		(ii)	$m = 3{\cdot}00 \times 10^3 - 1{\cdot}00 \times 10^3$ (1) $= 2{\cdot}00 \times 10^3$ (kg) $a = \frac{F}{m}$ (1) $a = \frac{40}{2{\cdot}00 \times 10^3}$ (1) $a = 0{\cdot}02$ m s^{-2} (1)	**4**	Or consistent with (c)(i) Calculation of mass may be implied by correct substitution. If no attempt to calculate the mass, or incorrect substitution to calculate the mass, then MAX (1) for equation. If clear arithmetic error in calculation of mass then MAX (3).

MARKS | DO NOT WRITE IN THIS MARGIN

13. Read the passage and answer the questions that follow.

Supernova explosion

The average temperature of the surface of the Sun is 5778 K. In the core of the Sun energy is produced by nuclear fusion. Once the Sun has used all its nuclear fuel it will collapse to form a white dwarf.

A star with a mass much larger than that of the Sun will end its life in an enormous explosion called a supernova. The energy released in a supernova explosion is more than a hundred times the energy that the Sun will radiate over its entire 10 billion year lifetime.

In our galaxy, the star Betelgeuse is predicted to explode in a supernova. Betelgeuse has a mass of around 8 times the mass of the Sun. Even though Betelgeuse is 640 light-years from Earth, the supernova will be as bright as a full moon at night in our sky.

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

(b) Determine the average temperature of the surface of the Sun in degrees Celsius. **1**

Space for working and answer

MARKS DO NOT WRITE IN THIS MARGIN

13. (continued)

(c) Show that the distance from Earth to Betelgeuse is $6{\cdot}1 \times 10^{18}$ m. **3**

Space for working and answer

(d) Betelgeuse may have already exploded in a supernova.

Explain this statement. **1**

[END OF QUESTION PAPER]

X757750131

Question			Answer	Max Mark	Additional Guidance
13.	(a)		(Two) nuclei combine (to form a larger nucleus). (1)	**1**	Do not accept: 'atoms' or 'particles' as an alternative to 'nuclei'
	(b)		5505 (°C) (1)	**1**	Unit not required but if stated must be correct.
	(c)		** SHOW THAT ** Must start with the correct equation or MAX (1) for speed of light $d = vt$ (1) $d = 3 \cdot 0 \times 10^8 \times$ (1) $(365 \cdot 25 \times 24 \times 60 \times 60 \times 640)$ (1) $d = 6 \cdot 1 \times 10^{18}$ m	**3**	Final answer of $6{\cdot}1 \times 10^{18}$ m or its numerical equivalent, including unit, must be shown, otherwise a maximum of (2) can be awarded (1) mark for initial equation (In this case, allow the equation to be preceded by a calculation of time and/or statement of the speed of light) (1) mark for obtaining speed of light from Data Sheet (independent mark) (1) mark for correct substitution of all parts of the time. Calculation can be done in stages, e.g. calculation of distance for one light-year, followed by multiplying this by 640. Accept number of days in a year to be 365. For alternative methods calculating v or t there must be final statement to show that calculated value of v is speed of light or t is equivalent to 640 years.
	(d)		The light/radiation from the explosion has not reached the Earth yet. **OR** The light/radiation takes time/640 years to reach Earth/to get here.	**1**	Do not accept: Explanation in terms of distance rather than time, eg 'It's 640 light-years away' alone.

[END OF MARKING INSTRUCTIONS]

N5 National Qualifications 2017

X757/75/02

Physics
Section 1 — Questions

WEDNESDAY, 17 MAY

1:00 PM – 3:00 PM

Instructions for the completion of Section 1 are given on *Page 02* of your question and answer booklet X757/75/01.

Record your answers on the answer grid on *Page 03* of your question and answer booklet.

Reference may be made to the Data Sheet on *Page 02* of this booklet and to the Relationship Sheet X757/75/11.

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

X757750 2

DATA SHEET

Speed of light in materials

Material	*Speed* in m s^{-1}
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	$2{\cdot}3 \times 10^8$

Gravitational field strengths

	Gravitational field strength on the surface in N kg^{-1}
Earth	9·8
Jupiter	23
Mars	3·7
Mercury	3·7
Moon	1·6
Neptune	11
Saturn	9·0
Sun	270
Uranus	8·7
Venus	8·9

Specific latent heat of fusion of materials

Material	*Specific latent heat of fusion* in J kg^{-1}
Alcohol	$0{\cdot}99 \times 10^5$
Aluminium	$3{\cdot}95 \times 10^5$
Carbon Dioxide	$1{\cdot}80 \times 10^5$
Copper	$2{\cdot}05 \times 10^5$
Iron	$2{\cdot}67 \times 10^5$
Lead	$0{\cdot}25 \times 10^5$
Water	$3{\cdot}34 \times 10^5$

Specific latent heat of vaporisation of materials

Material	*Specific latent heat of vaporisation* in J kg^{-1}
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	$22{\cdot}6 \times 10^5$

Speed of sound in materials

Material	*Speed* in m s^{-1}
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Specific heat capacity of materials

Material	*Specific heat capacity* in J kg^{-1} °C^{-1}
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Ice	2100
Iron	480
Lead	128
Oil	2130
Water	4180

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
Iron	1537	2737

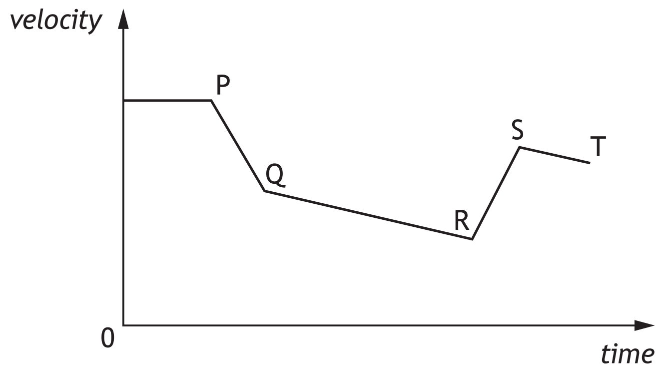
Radiation weighting factors

Type of radiation	*Radiation weighting factor*
alpha	20
beta	1
fast neutrons	10
gamma	1
slow neutrons	3
X-rays	1

SECTION 1

Attempt ALL questions

1. A cyclist is travelling along a straight road. The graph shows how the velocity of the cyclist varies with time.



The kinetic energy of the cyclist is greatest at

A P

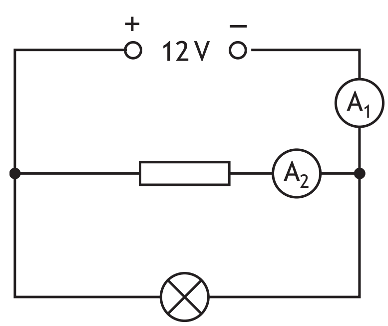
B Q

C R

D S

E T.

2. A circuit is set up as shown.



The reading on ammeter A_1 is 5·0 A. The reading on ammeter A_2 is 2·0 A.

The charge passing through the lamp in 30 seconds is

A 0·1 C

B 10 C

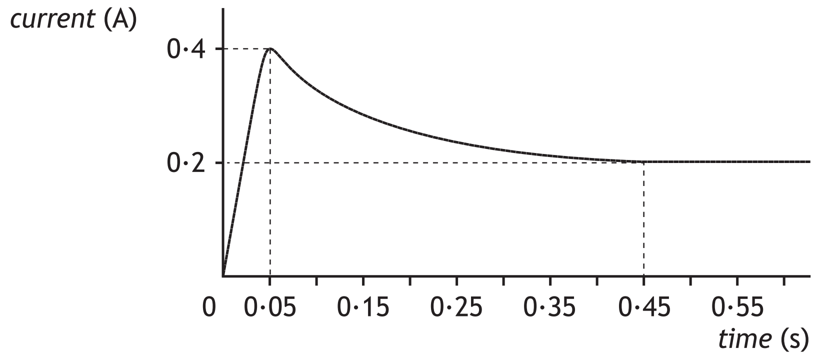
C 60 C

D 90 C

E 150 C.

3. A lamp is connected to a constant voltage power supply. The power supply is switched on.

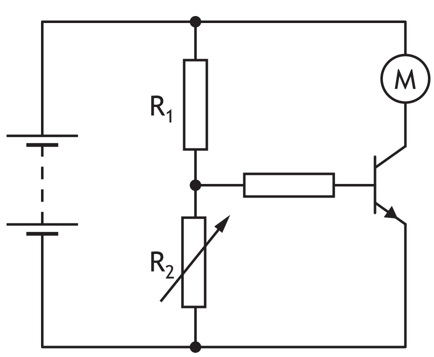
The graph shows how the current in the lamp varies with time.



Which row in the table shows what happens to the current and resistance of the lamp between 0·05 s and 0·45 s?

	Current	*Resistance*
A	decreases	increases
B	decreases	stays the same
C	stays the same	decreases
D	increases	decreases
E	increases	increases

4. A circuit is set up as shown.



The purpose of the transistor is to

A supply energy to the circuit

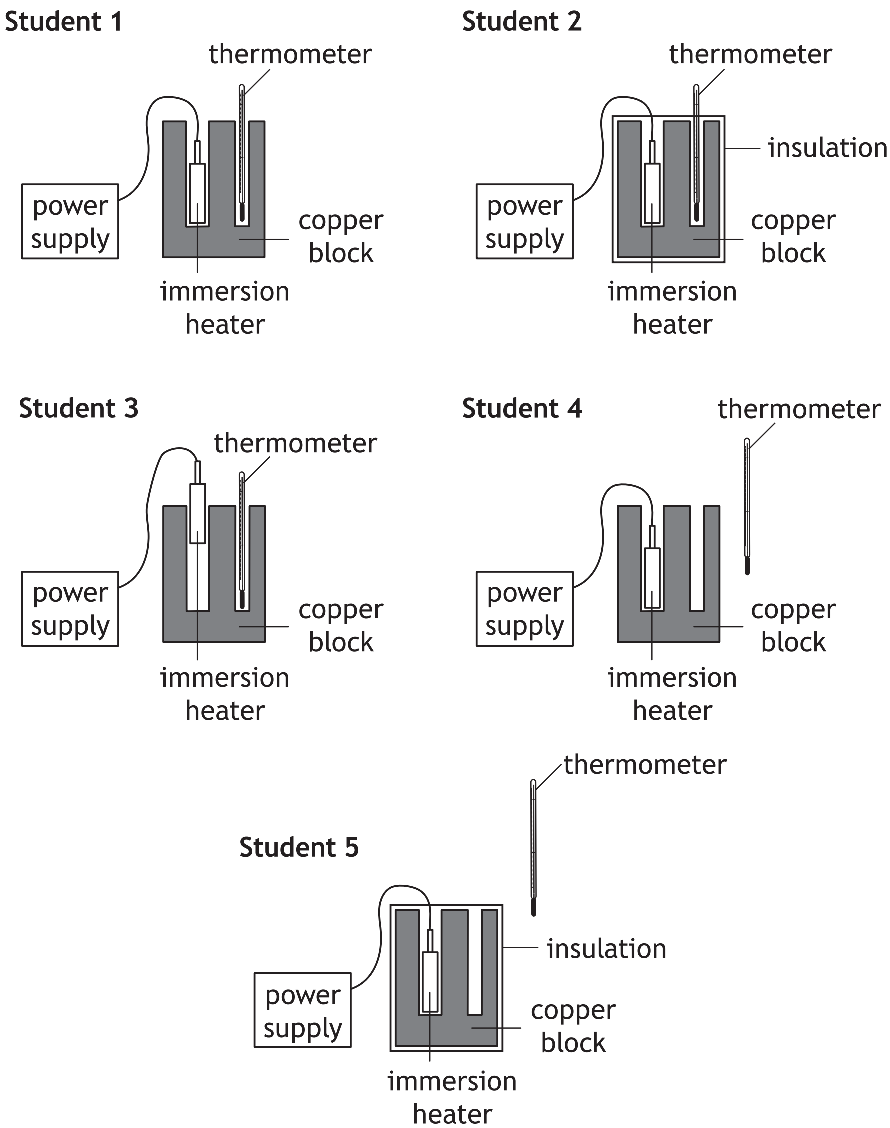
B decrease the voltage across R_1

C change electrical energy to kinetic energy

D supply energy to the motor

E switch on the motor.

5. Five students each carry out an experiment to determine the specific heat capacity of copper. The setup used by each student is shown.



The student with the setup that would allow the most accurate value for the specific heat capacity of copper to be determined is

A student 1

B student 2

C student 3

D student 4

E student 5.

[Turn over

6. The mass of a spacecraft is 1200 kg.

The spacecraft lands on the surface of a planet.

The gravitational field strength on the surface of the planet is $5{\cdot}0\,\text{N kg}^{-1}$.

The spacecraft rests on three pads. The total area of the three pads is $1{\cdot}5\,\text{m}^2$.

The pressure exerted by these pads on the surface of the planet is

A $1{\cdot}2 \times 10^4$ Pa

B $9{\cdot}0 \times 10^3$ Pa

C $7{\cdot}8 \times 10^3$ Pa

D $4{\cdot}0 \times 10^3$ Pa

E $8{\cdot}0 \times 10^2$ Pa.

7. A solid is heated from −15 °C to 60 °C. The temperature change of the solid is

A 45 K

B 75 K

C 258 K

D 318 K

E 348 K.

8. A student makes the following statements about waves.

I In a transverse wave, the particles vibrate parallel to the direction of travel of the wave.

II Light waves and water waves are both transverse waves.

III Sound waves are longitudinal waves.

Which of these statements is/are correct?

A I only

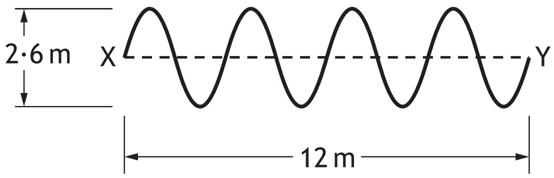
B II only

C III only

D I and II only

E II and III only

9. The diagram represents a wave travelling from X to Y.



The wave travels from X to Y in a time of 0·5 s.

Which row in the table shows the amplitude, wavelength and frequency of this wave?

	Amplitude (m)	*Wavelength* (m)	*Frequency* (Hz)
A	1·3	1·5	2·0
B	2·6	1·5	24
C	1·3	3·0	8·0
D	2·6	3·0	8·0
E	1·3	3·0	24

10. A microwave signal is transmitted by a radar station.

The signal is reflected from an aeroplane.

The aeroplane is at a height of 30 km directly above the radar station.

The time between the signal being transmitted and the reflected signal being received back at the radar station is

A 5×10^{-5} s

B 1×10^{-4} s

C 2×10^{-4} s

D 5×10^{3} s

E 1×10^{4} s.

[Turn over

11. A member of the electromagnetic spectrum has a shorter wavelength than visible light and a lower frequency than X-rays. This type of radiation is

A gamma

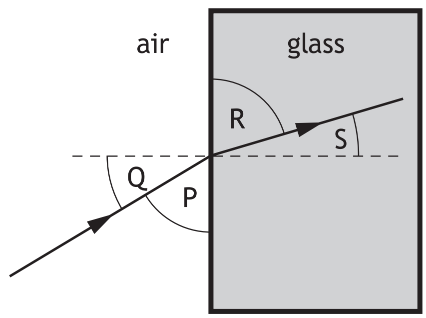
B ultraviolet

C infrared

D microwaves

E radio waves.

12. The diagram shows the path of a ray of red light as it passes from air into a glass block.



Which row in the table shows the angle of incidence and the angle of refraction?

	Angle of incidence	*Angle of refraction*
A	Q	S
B	S	Q
C	P	R
D	R	P
E	Q	R

13. A sample of tissue is exposed to 15 μGy of alpha radiation and 20 μGy of gamma radiation.

The total equivalent dose received by the tissue is

A 35 μSv

B 320 μSv

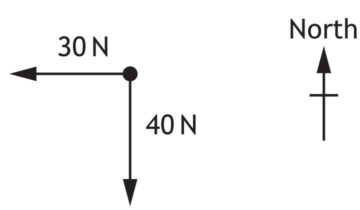
C 415 μSv

D 700 μSv

E 735 μSv.

14. Two forces act on an object as shown.

not to scale



The resultant force acting on the object is

A 50 N at a bearing of 053

B 50 N at a bearing of 143

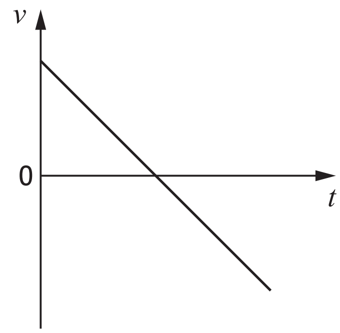
C 50 N at a bearing of 217

D 50 N at a bearing of 233

E 50 N at a bearing of 323.

[Turn over

15. The graph shows how the velocity v of an object varies with time t.



The graph could represent the motion of

A a ball falling freely downwards

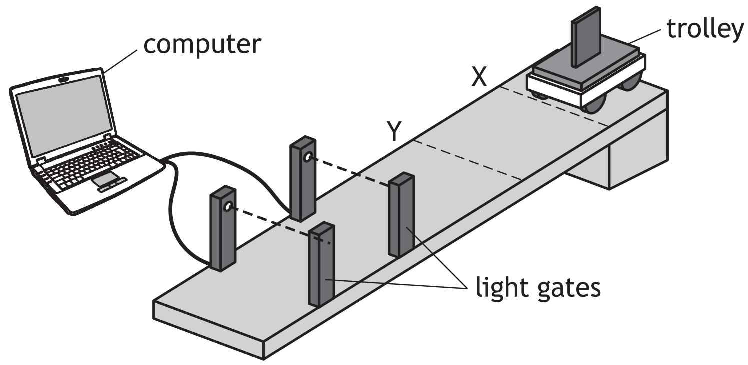
B a rocket accelerating upwards

C a ball thrown into the air then falling back to Earth

D a ball falling to Earth from rest then rebounding upwards again

E a car slowing to a halt then accelerating in the same direction.

16. A trolley is released from rest at point X and moves with constant acceleration on a slope as shown.



The computer displays the acceleration and average velocity of the trolley between the light gates.

The trolley is now released from rest at point Y.

Which row in the table shows how the acceleration and average velocity compare with the previous results obtained?

	Acceleration	*Average velocity*
A	less	same
B	same	same
C	greater	greater
D	less	less
E	same	less

[Turn over

17. A rocket accelerates vertically upwards from the surface of the Earth.

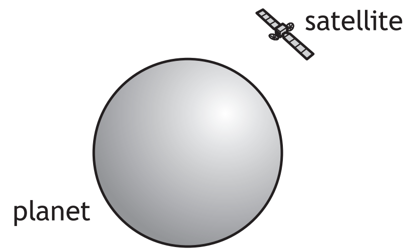
An identical rocket accelerates vertically upwards from the surface of Mars.

The engine thrust from each rocket is the same.

Which row in the table shows how the weight of the rocket and the unbalanced force acting on the rocket compares on Mars and Earth?

	Weight on Mars compared to weight on Earth	*Unbalanced force on Mars compared to unbalanced force on Earth*
A	greater	greater
B	same	same
C	same	less
D	less	greater
E	less	less

18. A satellite is in a circular orbit around a planet.



A group of students make the following statements about the satellite.

I The greater the altitude of a satellite the shorter its orbital period.

II The satellite has a constant vertical acceleration.

III As the satellite orbits the planet, its vertical velocity increases.

Which of these statements is/are correct?

A I only

B II only

C III only

D I and II only

E II and III only

19. A heater transfers energy to boiling water at the rate of 1130 joules every second.

The maximum mass of water converted to steam in 2 minutes is

A $1 \cdot 0 \times 10^{-3}$ kg

B $6 \cdot 0 \times 10^{-2}$ kg

C $0 \cdot 41$ kg

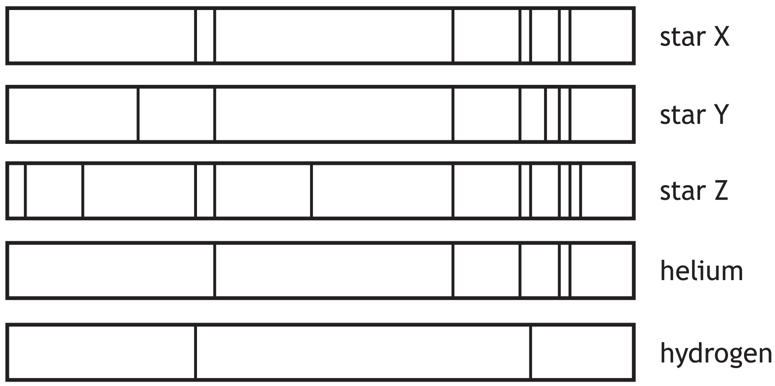
D 17 kg

E 32 kg.

[Turn over for next question

20. Light from stars can be split into line spectra of different colours.

The line spectra from three stars, X, Y and Z, are shown, along with the line spectra of the elements helium and hydrogen.



Hydrogen and helium are both present in

A star X only

B star Y only

C stars X and Y only

D stars X and Z only

E stars X, Y and Z.

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET]

Detailed marking instructions for each question

Section 1

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

Back to Table

FOR OFFICIAL USE

N5

National
Qualifications
2017

Mark

X757/75/01

Physics
Section 1 — Answer Grid
And Section 2

WEDNESDAY, 17 MAY

1:00 PM – 3:00 PM

* X 7 5 7 7 5 0 1 *

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 — 110

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

SECTION 2 — 90 marks
Attempt ALL questions.

Reference may be made to the Data Sheet on *Page 02* of the question paper X757/75/02 and to the Relationship Sheet X757/75/11.

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.

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

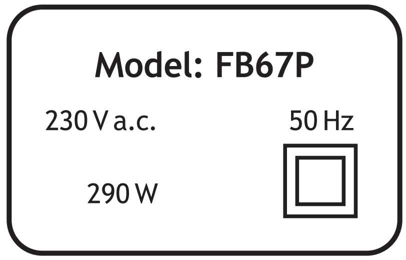
A/PB

Back to Table

SECTION 2 — 90 marks

Attempt ALL questions

1. The rating plate on a food blender is shown.



(a) The plugs on all modern electrical appliances in the UK are fitted with fuses rated at either 3 A or 13 A.

(i) Draw the circuit symbol for a fuse. **1**

(ii) State the purpose of the fuse fitted in the plug of an appliance. **1**

(iii) Determine the rating of the fuse fitted in the plug of the blender.

Justify your answer by calculation. **4**

Space for working and answer

MARKS DO NOT WRITE IN THIS MARGIN

1. (continued)

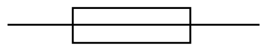
(b) The blender is connected to an alternating current (a.c.) supply.

Explain in terms of electron flow what is meant by *alternating current*. **1**

X757750107

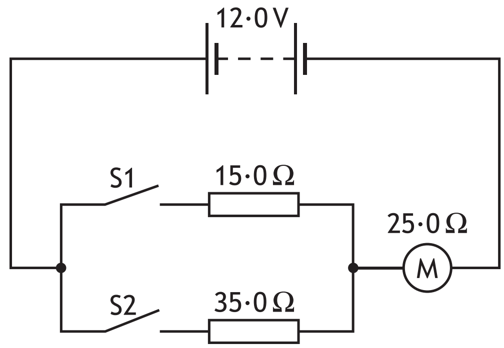
[Turn over

Section 2

Question			Answer	Max mark	Additional guidance
1.	(a)	(i)		**1**	
		(ii)	stops too large a current OR prevents wiring overheating OR protect wiring (from damage)	**1**	
		(iii)	3 A (fuse required) (1) $P = IV$ (1) $290 = I \times 230$ (1) $I = 1{\cdot}3\,(\text{A})$ (1)	**4**	Mark for selection of 3A fuse is independent. Accept 13 A fuse if consistent with arithmetic error in calculation of current. Can be done by calculating the maximum power rating for a 3A fuse: 3 A (fuse required) (1) $P = IV$ (1) $= 3 \times 230$ (1) $= 690\,(\text{W})$ (1)
	(b)		direction of electron (flow) (continually) changing back and forth/to and fro	**1**	Must answer in terms of electrons/charges (NOT current alone). Must indicate repeated changing of direction. Can be represented by a diagram indicating movement of electrons in both directions

MARKS | DO NOT WRITE IN THIS MARGIN

2. A student sets up the following circuit.



(a) The student closes switch S1.

(i) Calculate the voltage across the motor. **4**

Space for working and answer

(ii) Calculate the power dissipated in the motor. **3**

Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

2. (continued)

(b) The student now also closes switch S2.

(i) Calculate the combined resistance of the two resistors. **3**

Space for working and answer

(ii) State the effect that closing switch S2 has on the power dissipated in the motor.

Justify your answer. **3**

Question			Answer	Max mark	Additional guidance
2.	(a)	(i)	$R_T = 40{\cdot}0\ (\Omega)$ (1) $V = IR$ (1) $12{\cdot}0 = I \times 40{\cdot}0$ $(I = 0{\cdot}300\ A)$ $V = IR$ $= 0{\cdot}300 \times 25{\cdot}0$ (1) for all subs $= 7{\cdot}50\ V$ (1)	**4**	(1) for total resistance 40(·0) (1) for use of $V=IR$ (even if only stated once) (1) for both substitutions (1) for final answer and unit Accept 2-5 sig fig: 7·5 V 7·500 V 7·5000 V **Method 2:** $V_2 = \left(\frac{R_2}{R_1 + R_2}\right)V_S$ (1) $= \left(\frac{25\cdot0}{25\cdot0+15\cdot0}\right)\times 12\cdot0$ (1)+(1) $= 7\cdot50\ V$ (1)
		(ii)	$P = \frac{V^2}{R}$ (1) $= \frac{7\cdot50^2}{25\cdot0}$ (1) $= 2\cdot25\ \text{W}$ (1)	**3**	or consistent with (a)(i) for values of current and/or voltage Accept 2-5 sig fig: 2·3 W 2·250 W 2·2500 W **Method 2:** $P = I\,V$ (1) $= 0\cdot300 \times 7\cdot50$ (1) $= 2\cdot25\ \text{W}$ (1) **Method 3:** $P = I^2R$ (1) $= 0\cdot300^2 \times 25\cdot0$ (1) $= 2\cdot25\ \text{W}$ (1)

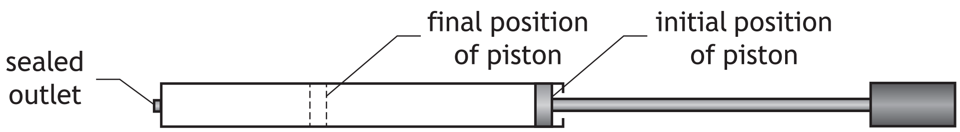
Question			Answer	Max mark	Additional guidance
2.	(b)	(i)	$\frac{1}{R_T}=\frac{1}{R_1}+\frac{1}{R_2}$ (1) $=\frac{1}{15\cdot0}+\frac{1}{35\cdot0}$ (1) $R_T = 10\cdot5\ \Omega$ (1)	**3**	Accept 2-5 sig fig: 11 Ω 10·50 Ω 10·500 Ω
		(ii)	(power dissipated is) greater/increased/higher (1) (combined/parallel/total) resistance less (1) voltage across motor is greater/increased OR current (in motor) is greater/increased (1)	**3**	Effect must be correct otherwise (0 marks) Do not accept: 'motor resistance is less' for second mark The effect can be established and/or justified by appropriate calculation(s). If this is done then effect must be correct for any marks to be awarded – award: (1) for correct calculation of total resistance (1) for correct voltage across motor or current in motor (1) for correct power or statement that power is greater

MARKS DO NOT WRITE IN THIS MARGIN

3. A bicycle pump with a sealed outlet contains $4{\cdot}0 \times 10^{-4}\,\text{m}^3$ of air.

The air inside the pump is at an initial pressure of $1{\cdot}0 \times 10^{5}\,\text{Pa}$.

The piston of the pump is now pushed slowly inwards until the volume of air in the pump is $1{\cdot}6 \times 10^{-4}\,\text{m}^3$ as shown.



During this time the temperature of the air in the pump remains constant.

(a) Calculate the final pressure of the air inside the pump. **3**

Space for working and answer

(b) Using the kinetic model, explain what happens to the pressure of the air inside the pump as its volume decreases. **3**

MARKS DO NOT WRITE IN THIS MARGIN

3. (continued)

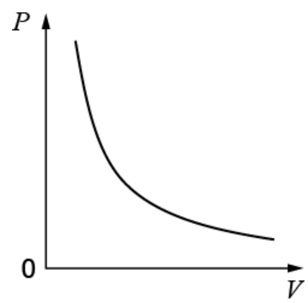
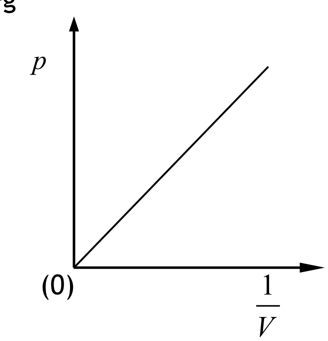
(c) The piston is now released, allowing it to move outwards towards its original position.

During this time the temperature of the air in the pump remains constant.

Using the axes provided, sketch a graph to show how the pressure of the air in the pump varies as its volume increases.

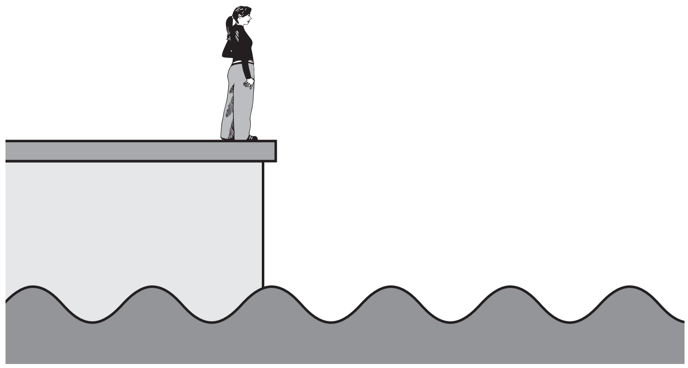
Numerical values are not required on either axis. **2**

(An additional diagram, if required, can be found on *Page 28*)

Question			Answer	Max mark	Additional guidance
3.	(a)		$p_1 V_1 = p_2 V_2$ (1) $1{\cdot}0 \times 10^5 \times 4{\cdot}0 \times 10^{-4} = p_2 \times 1{\cdot}6 \times 10^{-4}$ (1) $p_2 = 2{\cdot}5 \times 10^5$ Pa (1)	**3**	Accept 1-4 sig fig: 3×10^5 Pa $2{\cdot}50 \times 10^5$ Pa $2{\cdot}500 \times 10^5$ Pa
	(b)		(individual) particles collide with container/walls more frequently (than before) (1) (overall) force (on walls) is greater (1) pressure increases (1)	**3**	Independent marks.
	(c)		axes labelled p and V (1) correct shape (curved) (1) 	**2**	Axes may be transposed Accept for (2 marks) graph of p against $1/V$ (or V against $1/p$) labelled with a straight line through the origin, but origin does not need to be labelled eg 

MARKS | DO NOT WRITE IN THIS MARGIN

4. A student observes water waves entering a harbour.



(a) To determine the frequency of the waves, the student measures the time taken for a wave to pass a point at the harbour entrance.

The student measures this time to be 2·5 s

(i) Calculate the frequency of the waves. **3**

Space for working and answer

(ii) Suggest how the accuracy of the frequency determined by the student could be improved. **1**

4. (continued)

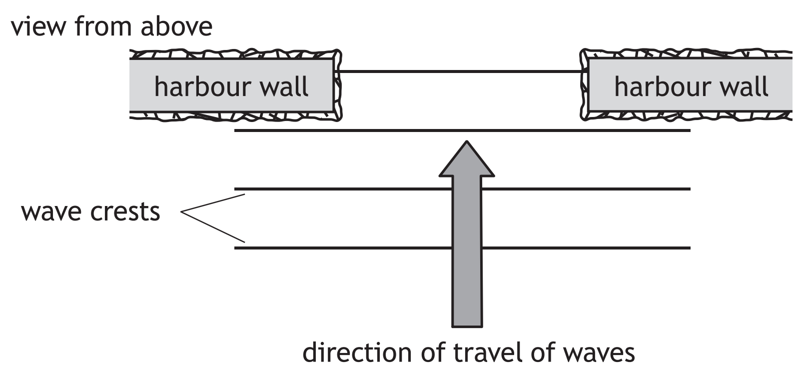
MARKS | DO NOT WRITE IN THIS MARGIN

(b) The distance between one wave crest and the next crest is 8·0 m.

Calculate the velocity of the waves. **3**

Space for working and answer

(c) Waves travel towards the entrance of the harbour as shown.

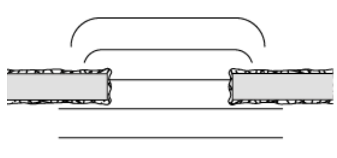


Complete the diagram to show the pattern of wave crests inside the harbour. **2**

(An additional diagram, if required, can be found on *Page 28*)

(d) As the waves pass into the harbour the student observes that the amplitude of the waves decreases.

Explain this observation. **1**

Question			Answer	Max mark	Additional guidance
4.	(a)	(i)	$T = \frac{1}{f}$ (1) $2 \cdot 5 = \frac{1}{f}$ (1) $f = 0 \cdot 40$ Hz (1)	3	Accept: $f = \frac{N}{t}$ Accept 1-4 sig fig: 0·4 Hz 0·400 Hz 0·4000 Hz
		(ii)	measure the time for more waves to pass OR count the number of waves in a longer period of time OR repeat (the measurement) <u>and</u> average	1	Do not accept answers relating to precision eg a stopclock with more decimal places.
	(b)		$v = f\lambda$ (1) $v = 0 \cdot 40 \times 8 \cdot 0$ (1) $v = 3 \cdot 2$ m s^{-1} (1)	3	Or consistent with (a)(i) Accept 1-4 sig fig: 3 m s^{-1} 3·20 ms^{-1} 3·200 ms^{-1} **Method 2:** $d = vt$ (1) $8 \cdot 0 = v \times 2 \cdot 5$ (1) $v = 3 \cdot 2$ m s^{-1} (1)
	(c)		diffraction of waves into 'shadow' regions behind walls (1) straight sections in middle and consistent wavelengths before and after gap (1) 	2	
	(d)		<u>energy</u> decreases/lost	1	Accept: description of <u>energy</u> being spread over greater area.

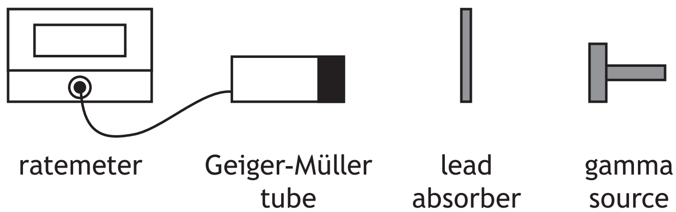
MARKS | DO NOT WRITE IN THIS MARGIN

5. Alpha, beta and gamma are types of nuclear radiation, which have a range of properties and effects.

Using your knowledge of physics, comment on the similarities and/or differences between these types of nuclear radiation. **3**

MARKS DO NOT WRITE IN THIS MARGIN

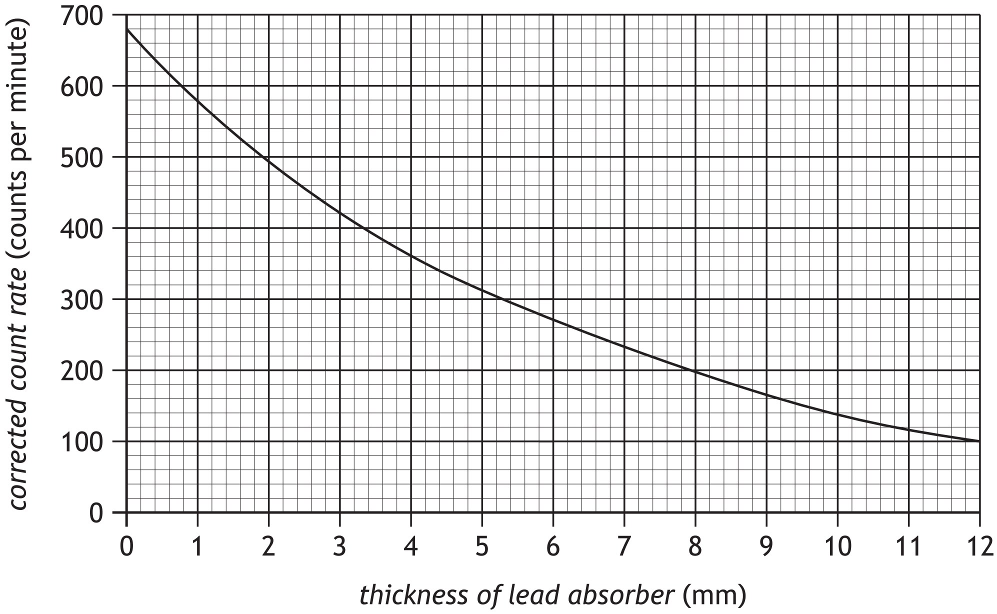
6\. A technician uses the apparatus shown to investigate the effect of shielding gamma radiation with lead.



Gamma radiation passing through a lead absorber is detected by a Geiger-Müller tube. The count rate is displayed on the ratemeter.

The count rates for a range of different thicknesses of lead absorber are recorded.

Using these results the technician produces a graph of corrected count rate against thickness of lead absorber as shown.



(a) State what additional measurement the technician must have made in order to determine the corrected count rate. **1**

MARKS | DO NOT WRITE IN THIS MARGIN

6. (continued)

(b) The half-value thickness of a material is the thickness of material required to reduce the corrected count rate from a source by half.

(i) Using the graph, determine the half-value thickness of lead for this source of gamma radiation. **1**

(ii) Determine the thickness of lead required to reduce the corrected count rate to one eighth of its initial value. **2**

Space for working and answer

(iii) The technician suggests repeating the experiment with aluminium absorbers instead of lead absorbers.

Predict how the half-value thickness of aluminium would compare to the half-value thickness of lead for this source. **1**

(c) When working with the radioactive source the technician is exposed to an equivalent dose rate of $2{\cdot}5 \times 10^{-6}\,\text{Sv}\,\text{h}^{-1}$.

The annual equivalent dose limit for the technician is 20 mSv.

Calculate the maximum number of hours the technician may work with this source without exceeding this limit. **3**

Space for working and answer

Question			Answer	Max mark	Additional guidance
6.	(a)		background count (rate)	**1**	
	(b)	(i)	4·4 mm	**1**	Accept answers in the range: 4·3 mm - 4·5 mm
		(ii)	Evidence of establishing 3 half-value thicknesses (1) (3 × 4·4) 13·2 mm (1)	**2**	Or consistent with (b)(i) Accept: 13 mm
		(iii)	greater	**1**	
	(c)		$\dot{H} = \frac{H}{t}$ (1) $2 \cdot 5 \times 10^{-6} = \frac{20 \times 10^{-3}}{t}$ (1) $t = 8000$ (h) (1)	**3**	

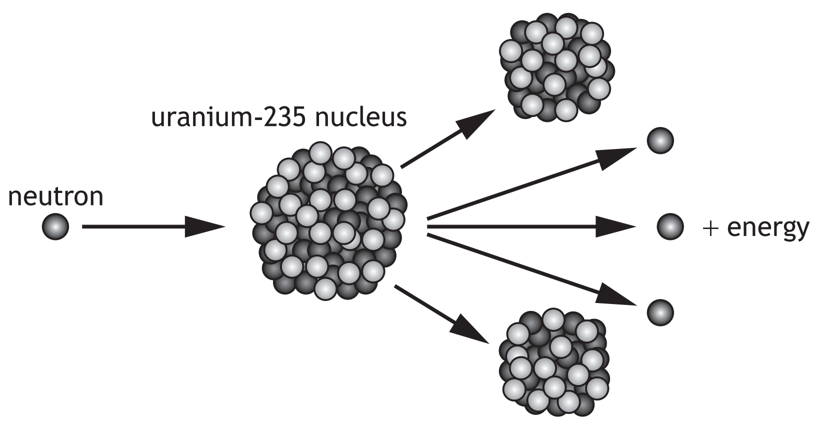
7. Nuclear reactions are used to generate electrical energy in a nuclear power station.

(a) The fuel for the power station is in the form of pellets, containing uranium-235.

A fuel pellet has an activity of 80 kBq.

State what is meant by an *activity of 80 kBq*. **1**

(b) In a nuclear reaction a uranium-235 nucleus is split by a neutron to produce two smaller nuclei, three neutrons, and energy.



MARKS DO NOT WRITE IN THIS MARGIN

7. (b) (continued)

(i) Explain how a single reaction can lead to the continuous generation of energy. **2**

(ii) One nuclear reaction releases $3{\cdot}2 \times 10^{-11}$ J.

In the reactor, $3{\cdot}0 \times 10^{21}$ reactions occur each minute.

Determine the maximum power output of the reactor. **4**

Space for working and answer

(c) The nuclear reactor produces waste that emits nuclear radiation.

State a use of nuclear radiation. **1**

* X 7 5 7 7 5 0 1 1 9 *

Question			Answer	Max mark	Additional guidance
7.	(a)		80 000 (nuclei) decay(s) per unit time	**1**	Accept: 'per second' in place of 'per unit time'
	(b)	(i)	neutrons can go on to cause further (fission) reactions/split more (uranium) nuclei (1) causing a chain reaction/this process repeats (1)	**2**	Independent marks.
		(ii)	$(E) = 3 \cdot 0 \times 10^{21} \times 3 \cdot 2 \times 10^{-11}$ (1) $= (9 \cdot 6 \times 10^{10}\ \text{J})$ $P = \frac{E}{t}$ (1) $= \frac{9 \cdot 6 \times 10^{10}}{60}$ (1) $= 1 \cdot 6 \times 10^{9}\ \text{W}$ (1)	**4**	**Method 2:** $A = \frac{N}{t}$ (1) $= \frac{3 \cdot 0 \times 10^{21}}{60}$ (1) $= (5 \times 10^{19}\ \text{Bq})$ $P = 5 \times 10^{19} \times 3 \cdot 2 \times 10^{-11}$ (1) $= 1 \cdot 6 \times 10^{9}\ \text{W}$ (1) Calculation of power of one decay over a minute then multiplication by number of decays per minute is wrong physics MAX (1) for relationship
	(c)		any suitable use (eg treating cancer/tracers/ sterilisation/smoke detectors/ measuring thickness of paper)	**1**	Must be a use of nuclear radiation

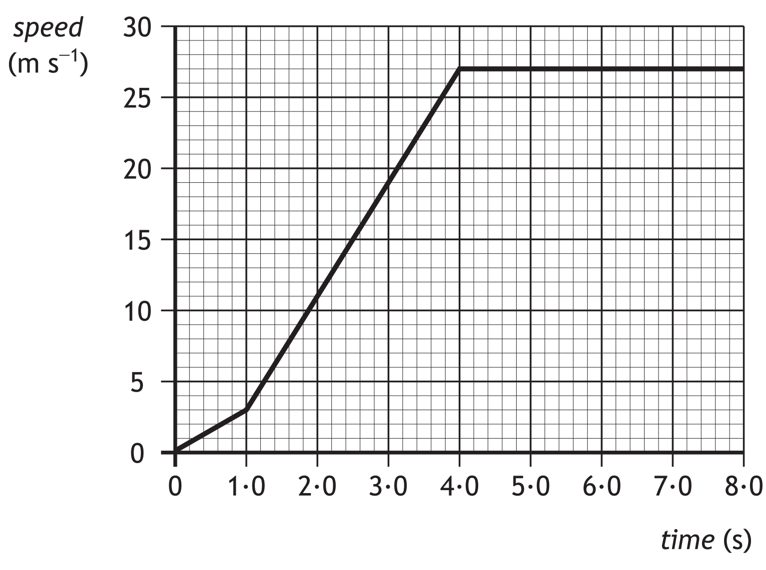
MARKS | DO NOT WRITE IN THIS MARGIN

8. In speedway, motorbikes are raced anticlockwise round an oval track.

A race consists of four laps of a 380 m track.

(a) State the displacement of a motorbike from the start line to the finish line for a complete race. **1**

(b) The speed-time graph of a motorbike for the first 8·0 s of a race is shown.



MARKS | DO NOT WRITE IN THIS MARGIN

8. (b) (continued)

(i) Calculate the distance travelled by the motorbike in the first 4·0 s of the race. **3**

Space for working and answer

(ii) Determine the **greatest** acceleration of the motorbike during the first 8·0 s of the race. **3**

Space for working and answer

(c) The winner of the race completes all four laps in a time of 79 s.

Calculate the average speed of the winner. **3**

Space for working and answer

Question			Answer	Max mark	Additional guidance
8.	(a)		0 (m)	**1**	Ignore any mention of direction.
	(b)	(i)	d = *area under graph* (1) $= (0\cdot5\times1\times3)$ $+ (0\cdot5\times3\times24) + (3\times3)$ (1) $= 46\cdot5$ m (1)	**3**	If incorrect substitution then MAX (1) for (implied) relationship. Any attempt to use $d = \bar{v}t$ (or $s = \bar{v}t$) applied to first 4 s is wrong physics, award (0 marks). If $d = \bar{v}t$ (or $s = \bar{v}t$) is used for each section of the graph and the results added to give the correct total distance then full marks can be awarded. Accept 1-3 sig fig: 50 m 47 m
		(ii)	$a = \dfrac{v - u}{t}$ (1) $a = \dfrac{27 - 3}{3\cdot0}$ (1) $a = 8$ m s^{-2} (1)	**3**	Accept: $a = \dfrac{\Delta v}{t}$ $v = u + at$ Do not accept a response starting with: $a = \dfrac{v}{t}$ OR $v = at$ Accept 1-3 sig fig: 8·0 m s^{-2} 8·00 m s^{-2}
	(c)		$d = \bar{v}t$ (1) $4\times380 = \bar{v} \times 79$ (1) $\bar{v} = 19$ m s^{-1} (1)	**3**	Bar not required above v Accept: calculation of average time for one lap then division of distance of one lap by this time. Accept 1-4 sig fig: 20 m s^{-1} 19·2 m s^{-1} 19·24 m s^{-1}

MARKS | DO NOT WRITE IN THIS MARGIN

9. A weightlifter applies an upwards force of 1176 N to a barbell to hold it in a stationary position as shown.

(a) Describe how the upward force exerted by the weightlifter on the barbell compares to the weight of the barbell. **1**

(b) Calculate the mass of the barbell. **3**

Space for working and answer

(c) The weightlifter increases the upward force on the barbell to 1344 N in order to lift the barbell above their head.

Calculate the initial acceleration of the barbell. **4**

Space for working and answer

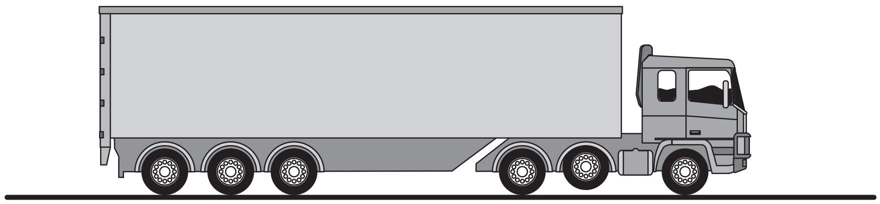
* X 7 5 7 7 5 0 1 2 2 *

Question			Answer	Max mark	Additional guidance
9.	(a)		(The forces are) equal (in size) <u>and</u> opposite (in direction).	**1**	Accept: '(The forces are) balanced'
	(b)		$W = mg$ (1) $1176 = m \times 9 \cdot 8$ (1) $m = 120$ kg (1)	**3**	Use of $F=ma$ is wrong physics - award (0 marks)
	(c)		$F = 1344 - 1176 = 168$ (N) (1) $F = ma$ (1) $168 = 120 \times a$ (1) $a = 1 \cdot 4$ m s^{-2} (1)	**4**	Or consistent with (b) Accept 1-4 sig fig: 1 m s^{-2} 1·40 m s^{-2} 1·400 m s^{-2}

MARKS | DO NOT WRITE IN THIS MARGIN

10. An articulated lorry has six pairs of wheels.

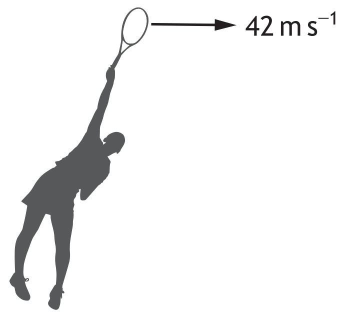
One pair of wheels can be raised off the ground.



Using your knowledge of physics, comment on situations in which the wheels may be raised or lowered. **3**

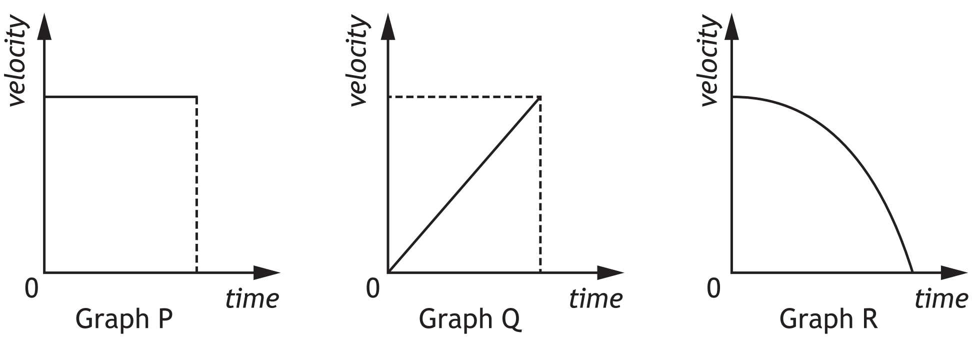
MARKS | DO NOT WRITE IN THIS MARGIN

11. A tennis player serves a tennis ball horizontally at a velocity of $42\,\text{m s}^{-1}$.



The effects of air resistance are negligible.

(a) State which of the following graphs P, Q or R shows the vertical velocity of the ball after it leaves the player's racquet. **1**



Graph: ________________

(b) In a second serve the player hits the ball horizontally with a smaller velocity from the same height.

State whether the time taken for the ball to reach the ground is less than, equal to, or greater than the time taken in the first serve.

Justify your answer. **2**

MARKS DO NOT WRITE IN THIS MARGIN

11. (continued)

(c) The tennis court has a retractable roof to allow play to continue in all weather conditions.

It requires 5·5 kJ of energy to move one section of the roof a distance of 25 m.

Calculate the average force acting on this section of the roof while it is being moved. **3**

Space for working and answer

* X 7 5 7 7 5 0 1 2 5 *

[Turn over for next question

Question			Answer	Max mark	Additional guidance
11.	(a)		Q	**1**	
	(b)		equal (to) (1) vertical/downward acceleration is the same (1)	**2**	Effect must be correct otherwise (0 marks)
	(c)		$E_w = Fd$ (1) $5500 = F \times 25$ (1) $F = 220\ \text{N}$ (1)	**3**	Accept 1-4 sig fig: 200 N 220·0 N

MARKS | DO NOT WRITE IN THIS MARGIN

12. The star Wolf 359 is at a distance of 7·8 light-years from Earth.

A radio signal from Wolf 359 is detected by a radio telescope on Earth.

(a) (i) State the speed of the radio waves. **1**

(ii) Calculate the distance, in metres, from Wolf 359 to Earth. **3**

Space for working and answer

(b) Another telescope is used to observe the same star in the visible part of the spectrum.

(i) State a suitable detector of visible light that may be used in this telescope. **1**

(ii) State whether the time taken for the visible light from the star to reach Earth is less than, equal to, or greater than the time taken for the radio waves from the star to reach Earth. **1**

[END OF QUESTION PAPER]

12.	(a)	(i)	$3{\cdot}0 \times 10^8$ m s^{-1}	**1**	Accept: 3×10^8 m s^{-1} 300 000 000 m s^{-1}
		(ii)	$d = vt$ (1) $d = 3\cdot0\times10^8 \times(7\cdot8\times365\cdot25\times24\times60\times60)$ (1) $d = 7\cdot4\times10^{16}$ (m) (1)	**3**	Accept 1-4 sig fig: 7×10^{16} (m) $7{\cdot}38 \times 10^{16}$ (m) $7{\cdot}384 \times 10^{16}$ (m) Also accept, if using 365 days: $7{\cdot}379 \times 10^{16}$ (m)
	(b)	(i)	photographic film	**1**	Accept: 'charge coupled device'/'CCD' 'photodiode' 'phototransistor' 'retina (of the eye)' 'LDR'
		(ii)	equal (to)	**1**	Accept equivalent statement (eg 'same')

[END OF MARKING INSTRUCTIONS]

N5 National Qualifications SPECIMEN ONLY

S857/75/02

Physics
Section 1 — Questions

Date — Not applicable

Duration — 2 hours 30 minutes

Instructions for completion of Section 1 are given on *page 02* of your question and answer booklet S857/75/01.

Record your answers on the answer grid on *page 03* of your question and answer booklet.

Reference may be made to the Data Sheet on *page 02* of this booklet and to the Relationships Sheet S857/75/11.

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

S85775O2

Back to Table

DATA SHEET

Speed of light in materials

Material	*Speed* in m s^{-1}
Air	$3\cdot0 \times 10^8$
Carbon dioxide	$3\cdot0 \times 10^8$
Diamond	$1\cdot2 \times 10^8$
Glass	$2\cdot0 \times 10^8$
Glycerol	$2\cdot1 \times 10^8$
Water	$2\cdot3 \times 10^8$

Gravitational field strengths

	Gravitational field strength on the surface in N kg^{-1}
Earth	9·8
Jupiter	23
Mars	3·7
Mercury	3·7
Moon	1·6
Neptune	11
Saturn	9·0
Sun	270
Uranus	8·7
Venus	8·9

Specific latent heat of fusion of materials

Material	*Specific latent heat of fusion* in J kg^{-1}
Alcohol	$0\cdot99 \times 10^5$
Aluminium	$3\cdot95 \times 10^5$
Carbon Dioxide	$1\cdot80 \times 10^5$
Copper	$2\cdot05 \times 10^5$
Iron	$2\cdot67 \times 10^5$
Lead	$0\cdot25 \times 10^5$
Water	$3\cdot34 \times 10^5$

Specific latent heat of vaporisation of materials

Material	*Specific latent heat of vaporisation* in J kg^{-1}
Alcohol	$11\cdot2 \times 10^5$
Carbon Dioxide	$3\cdot77 \times 10^5$
Glycerol	$8\cdot30 \times 10^5$
Turpentine	$2\cdot90 \times 10^5$
Water	$22\cdot6 \times 10^5$

Speed of sound in materials

Material	*Speed* in m s^{-1}
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Specific heat capacity of materials

Material	*Specific heat capacity* in J kg^{-1} °C^{-1}
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Ice	2100
Iron	480
Lead	128
Oil	2130
Water	4180

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
Iron	1537	2737

Radiation weighting factors

Type of radiation	*Radiation weighting factor*
alpha	20
beta	1
fast neutrons	10
gamma	1
slow neutrons	3
X-rays	1

Back to Table

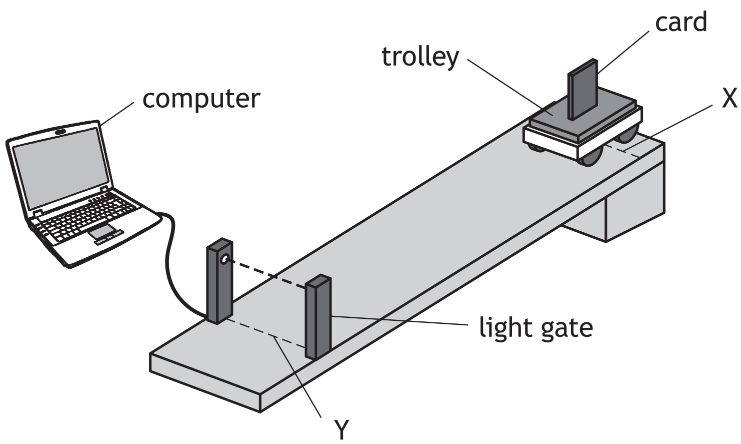
SECTION 1

Attempt ALL questions

1. Which of the following contains two scalar quantities?

A Force and mass
B Weight and mass
C Displacement and speed
D Distance and speed
E Displacement and velocity

2. A student sets up the apparatus as shown.



The trolley is released from X and moves down the ramp.

The following measurements are recorded.

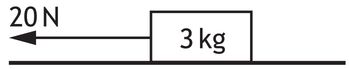
time for card to pass through light gate = 0·080 s
distance from X to Y = 0·50 m
length of card = 0·040 m

The instantaneous speed of the trolley at Y is

A 0·50 m s^{-1}
B 1·6 m s^{-1}
C 2·0 m s^{-1}
D 3·2 m s^{-1}
E 6·3 m s^{-1}.

[Turn over

3. A block of mass 3 kg is pulled across a horizontal bench by a force of 20 N as shown below.



The block accelerates at $4\,m\,s^{-2}$.

The force of friction between the block and the bench is

A 0 N

B 8 N

C 12 N

D 20 N

E 32 N.

4. An aircraft engine exerts a force on the air.

Which of the following completes the 'Newton pair' of forces?

A The force of the air on the aircraft engine.

B The force of friction between the aircraft engine and the air.

C The force of the aircraft engine on the aircraft.

D The force of the Earth on the aircraft engine.

E The force of the aircraft engine on the Earth.

5. A trolley of mass 0·50 kg has a kinetic energy of 0·36 J.

The speed of the trolley is

A $0{\cdot}60\,m\,s^{-1}$

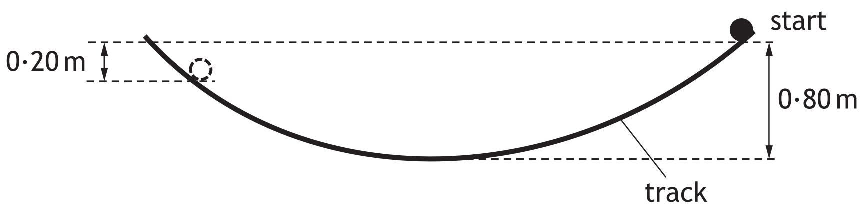
B $0{\cdot}85\,m\,s^{-1}$

C $1{\cdot}2\,m\,s^{-1}$

D $1{\cdot}44\,m\,s^{-1}$

E $1{\cdot}7\,m\,s^{-1}$.

6. A ball is released from rest and allowed to roll down a curved track as shown.



The mass of the ball is 0·50 kg.

The maximum height reached on the opposite side of the track is 0·20 m lower than the height of the starting point.

The amount of energy lost is

A 0·080 J

B 0·10 J

C 0·98 J

D 2·9 J

E 3·9 J.

7. The Mars Curiosity Rover has a mass of 900 kg.

Which row of the table gives the mass and weight of the Rover on Mars?

	Mass (kg)	*Weight* (N)
A	243	243
B	243	900
C	900	900
D	900	3330
E	900	8820

[Turn over

8. A student makes the following statements about the Universe.

I The Big Bang Theory is a theory about the origin of the Universe.

II The Universe is approximately 14 million years old.

III The Universe is expanding.

Which of these statements is/are correct?

A I only

B II only

C I and II only

D I and III only

E I, II and III

9. A conductor carries a current of $4{\cdot}0\,\mu A$ for $250\,s$.

The total charge passing a point in the conductor is

A $1{\cdot}6 \times 10^{-8}\,C$

B $1{\cdot}0 \times 10^{-3}\,C$

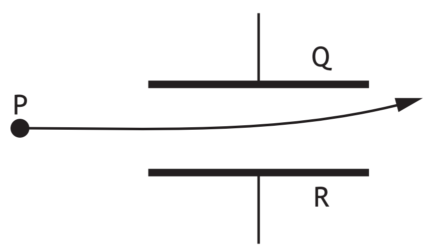
C $6{\cdot}25 \times 10^{1}\,C$

D $1{\cdot}0 \times 10^{3}\,C$

E $6{\cdot}25 \times 10^{7}\,C$.

10. A uniform electric field exists between plates Q and R.

The diagram shows the path taken by a particle as it passes through the field.



Which row in the table identifies the charge on the particle, the charge on plate Q and the charge on plate R?

	Charge on particle	*Charge on plate Q*	*Charge on plate R*
A	negative	positive	negative
B	negative	negative	positive
C	no charge	negative	positive
D	no charge	positive	negative
E	positive	positive	negative

11. 1 volt is equivalent to

A 1 ampere per watt

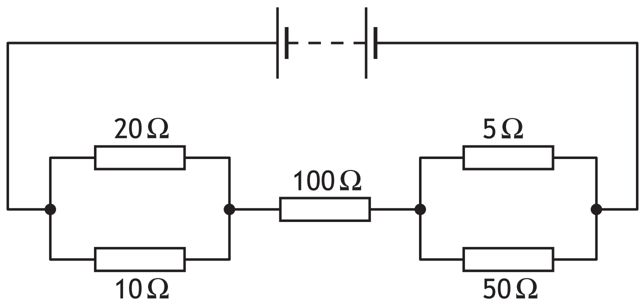
B 1 coulomb per second

C 1 joule per coulomb

D 1 joule per second

E 1 watt per second.

12. In the circuit shown, the current in each resistor is different.



In which resistor is the current smallest?

A 5 Ω

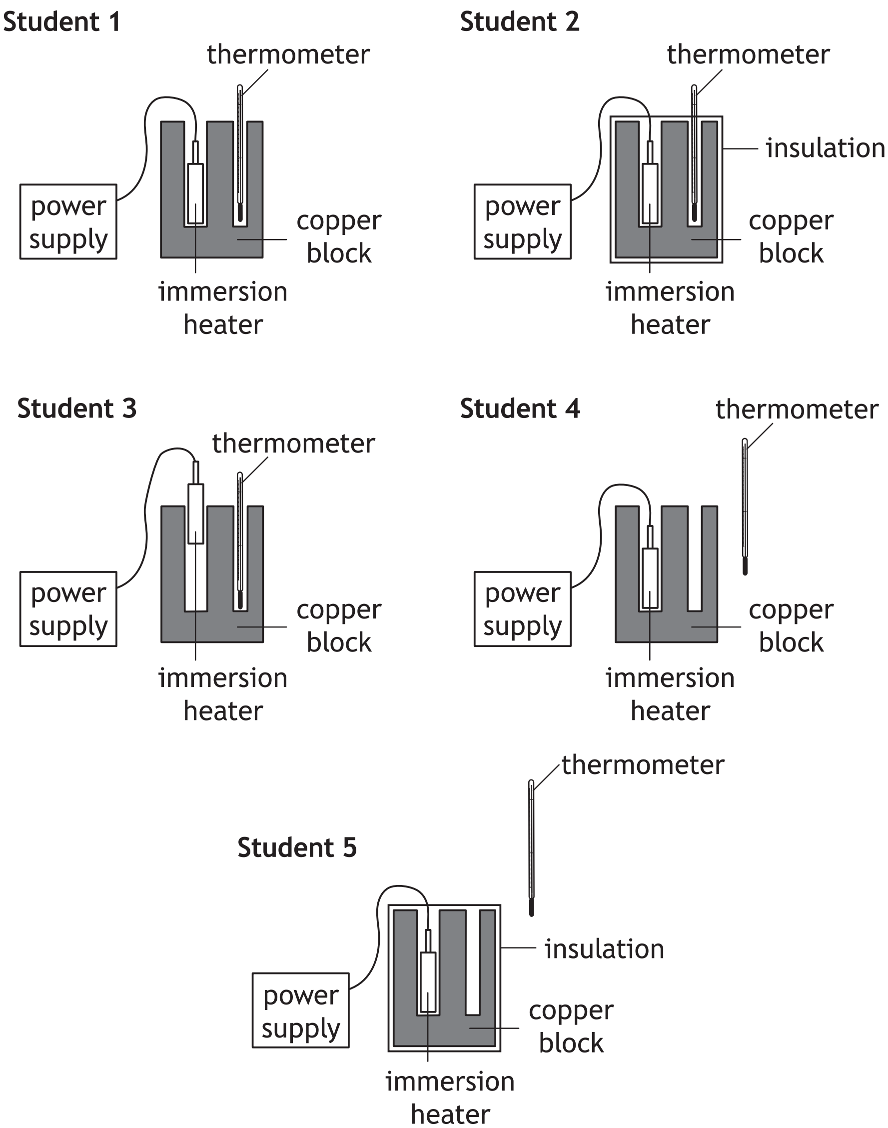
B 10 Ω

C 20 Ω

D 50 Ω

E 100 Ω

13. Five students each carry out an experiment to determine the specific heat capacity of copper. The setup used by each student is shown.



The student with the setup that would allow the most accurate value for the specific heat capacity of copper to be determined is

A student 1

B student 2

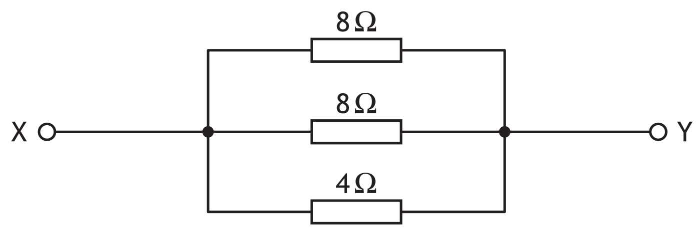
C student 3

D student 4

E student 5.

[Turn over

14. Three resistors are connected as shown.



The resistance between X and Y is

A 0·08 Ω

B 0·5 Ω

C 2 Ω

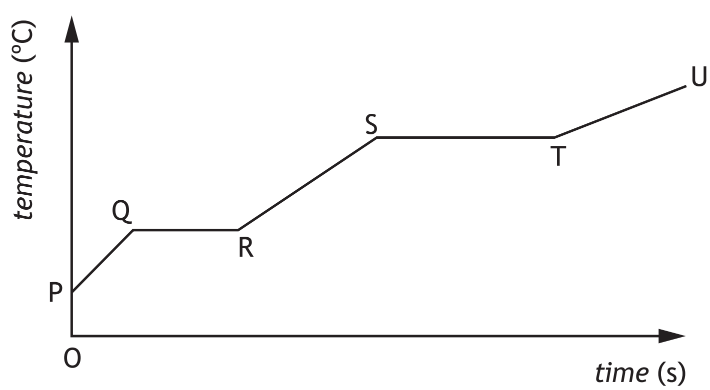
D 13 Ω

E 20 Ω.

15. A heater is immersed in a substance.

The heater is then switched on.

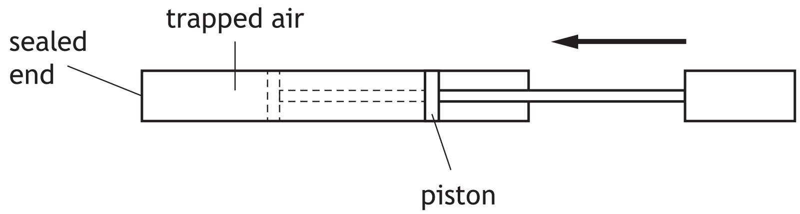
The graph shows the temperature of the substance over a period of time.



Which row in the table identifies the sections of the graph when the substance is changing state?

	Solid to liquid	*Liquid to gas*
A	QR	TU
B	QR	ST
C	PQ	RS
D	PQ	TU
E	ST	QR

16. A bicycle pump is sealed at one end and the piston pushed until the pressure of the trapped air is $4{\cdot}00 \times 10^{5}$ Pa.



The area of the piston compressing the air is $5{\cdot}00 \times 10^{-4}\,\text{m}^2$.

The force that the trapped air exerts on the piston is

A $1{\cdot}25 \times 10^{-9}$ N

B $8{\cdot}00 \times 10^{-1}$ N

C $2{\cdot}00 \times 10^{2}$ N

D $8{\cdot}00 \times 10^{8}$ N

E $2{\cdot}00 \times 10^{10}$ N.

17. A liquid is heated from 17 °C to 50 °C. The temperature rise in kelvin is

A 33 K

B 67 K

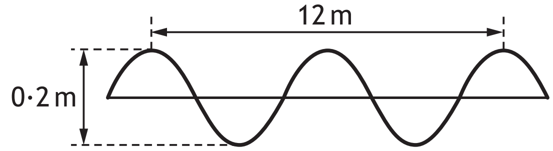
C 306 K

D 340 K

E 579 K.

[Turn over

18. The following diagram shows a wave.



Which row in the table gives the wavelength and amplitude of the wave?

	Wavelength (m)	*Amplitude* (m)
A	4	0·2
B	6	0·1
C	6	0·2
D	12	0·1
E	12	0·2

19. A wave machine in a swimming pool generates 15 waves per minute.

The wavelength of these waves is 2·0 m.

The frequency of the waves is

A 0·25 Hz

B 0·50 Hz

C 4·0 Hz

D 15 Hz

E 30 Hz.

[Turn over

20. The diagram shows members of the electromagnetic spectrum in order of increasing wavelength.

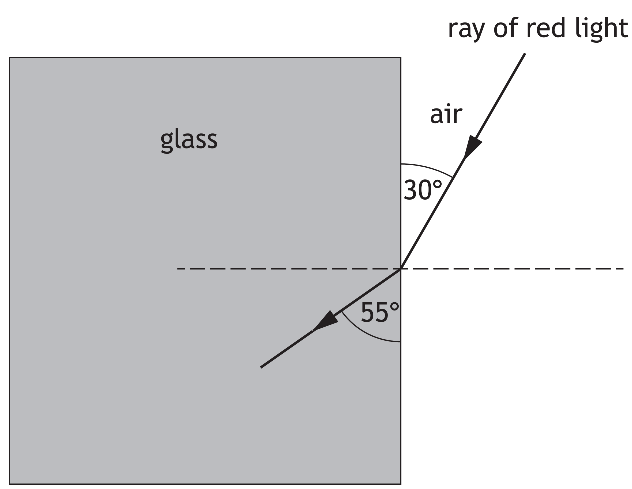
Gamma rays	P	Ultraviolet radiation	Q	Infrared radiation	R	TV and radio waves

increasing wavelength →

Which row in the table identifies the radiations represented by the letters P, Q and R?

	P	*Q*	*R*
A	X-rays	visible light	microwaves
B	X-rays	microwaves	visible light
C	microwaves	visible light	X-rays
D	visible light	microwaves	X-rays
E	visible light	X-rays	microwaves

21. A ray of red light is incident on a glass block as shown.



Which row in the table shows the values of the angle of incidence and angle of refraction?

	Angle of incidence	*Angle of refraction*
A	35°	60°
B	30°	55°
C	30°	35°
D	60°	55°
E	60°	35°

22. Which of the following describes the term ionisation?

A An atom losing an orbiting electron.

B An atom losing a proton.

C A nucleus emitting an alpha particle.

D A nucleus emitting a neutron.

E A nucleus emitting a gamma ray.

23. A student writes the following statements about the activity of a radioactive source.

I The activity decreases with time.

II The activity is measured in becquerels.

III The activity is the number of decays per second.

Which of these statements is/are correct?

A I only

B II only

C I and II only

D II and III only

E I, II and III

24. A worker in a nuclear power station is exposed to 3·00 mGy of gamma radiation and 0·500 mGy of fast neutrons.

The total equivalent dose received by the worker is

A 3·50 mSv

B 8·00 mSv

C 30·5 mSv

D 35·0 mSv

E 38·5 mSv.

[Turn over

25. In a nuclear reactor a chain reaction releases energy from nuclei.

Which of the following statements describes the beginning of a chain reaction?

A An electron splits a nucleus releasing more electrons.

B An electron splits a nucleus releasing protons.

C A proton splits a nucleus releasing more protons.

D A neutron splits a nucleus releasing electrons.

E A neutron splits a nucleus releasing more neutrons.

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET]

Marking instructions for each question

Section 1

Question	Answer	Max mark
1.	D	1
2.	A	1
3.	B	1
4.	A	1
5.	C	1
6.	C	1
7.	D	1
8.	D	1
9.	B	1
10.	A	1
11.	C	1
12.	D	1
13.	B	1
14.	C	1
15.	B	1
16.	C	1
17.	A	1
18.	B	1
19.	A	1
20.	A	1
21.	E	1
22.	A	1
23.	E	1
24.	B	1
25.	E	1

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Mark

S857/75/01

Physics
Section 1 — Answer Grid
And Section 2

Date — Not applicable

Duration — 2 hours 30 minutes

S857750 1

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 — 135

SECTION 1 — 25 marks
Attempt ALL questions.
Instructions for 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 S857/75/02 and to the Relationships Sheet S857/75/11.

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. 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.

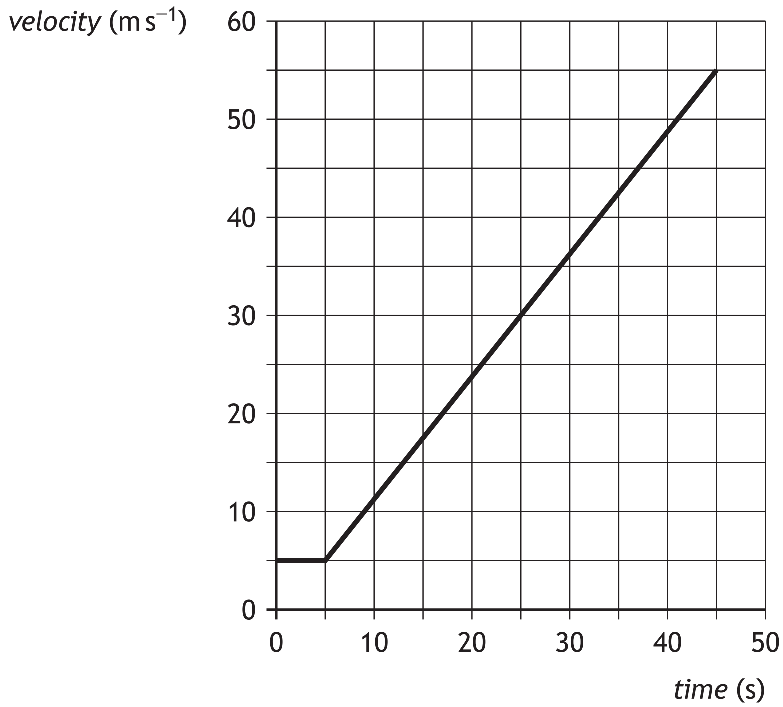
S85775010 1

MARKS DO NOT WRITE IN THIS MARGIN

SECTION 2 — 110 marks

Attempt ALL questions

1. An aircraft is making a journey between two airports. A graph of the aircraft's velocity during take-off is shown.



(a) Calculate the acceleration of the aircraft during take-off. **3**

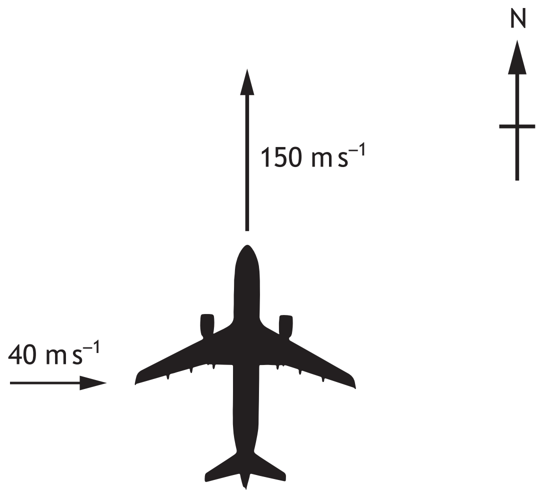
Space for working and answer

S857750105

1. (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(b) During flight, the aircraft is travelling at a velocity of $150\,\mathrm{m\,s^{-1}}$ due north and then encounters a crosswind of $40\,\mathrm{m\,s^{-1}}$ due east.



By scale diagram, or otherwise, determine:

(i) the magnitude of the resultant velocity of the aircraft; **2**

Space for working and answer

(ii) the direction of the resultant velocity of the aircraft. **2**

Space for working and answer

1. (continued)

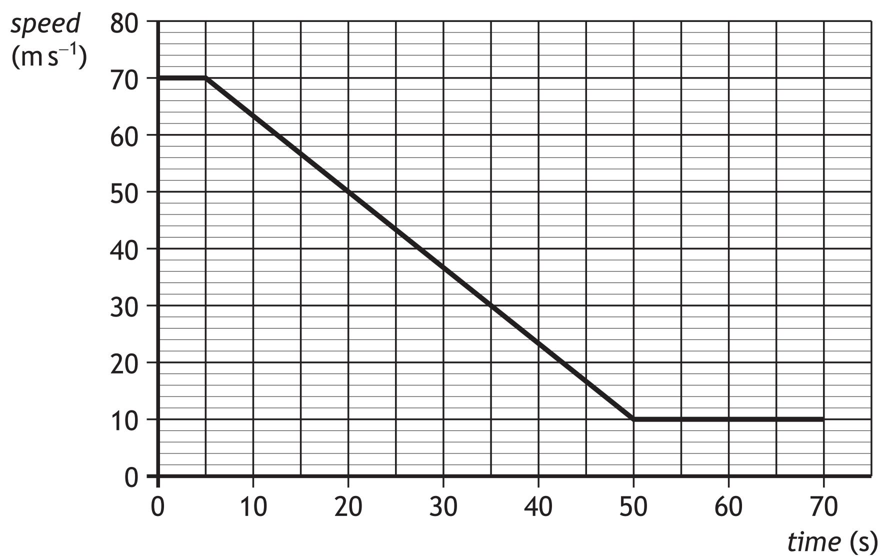
MARKS DO NOT WRITE IN THIS MARGIN

(c) The aircraft arrives at the destination airport.

There are three runways, X, Y and Z, available for the aircraft to land on. The length of each runway is given in the table.

Runway	*Length* (m)
X	3776
Y	3048
Z	2743

(i) The speed-time graph below shows the speed of the aircraft during landing on the runway, from the moment the wheels touch down.



Determine which runways the aircraft could have used to land safely.

Justify your answer by calculation. **4**

Space for working and answer

* S 8 5 7 7 5 0 1 0 7 *

1. (c) (continued)

MARKS DO NOT WRITE IN THIS MARGIN

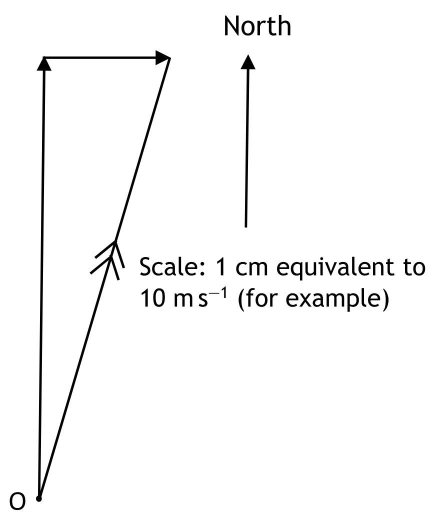
(ii) This airport has runways of different lengths to accommodate different sizes of aircraft.

Explain why larger aircraft require a longer runway to land safely. **2**

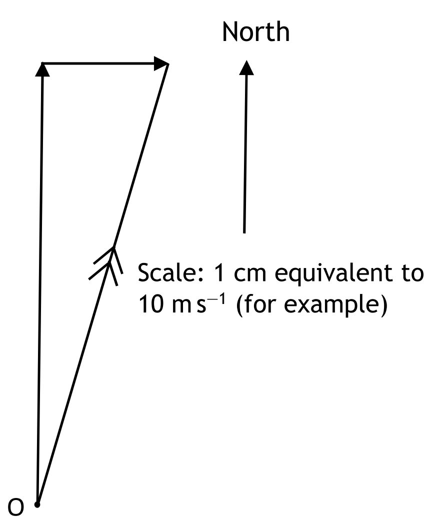
S857750108

Section 2

Question			Expected response	Max mark	Additional guidance
1.	(a)		$a = \dfrac{v-u}{t}$ 1 $a = \dfrac{55-5}{40}$ 1 $a = 1{\cdot}25\ \text{m s}^{-2}$ 1	**3**	Accept 1·3, 1·250, 1·2500 Accept $a =$ gradient and substitution of data points from appropriate line
	(b)	(i)	Scale diagram v=155±3 m s^{-1}	**2**	Pythagoras $v = \sqrt{150^2 + 40^2}$ 1 $v = 155\ \text{m s}^{-1}$ 1 Accept 150, 155·2, 155·24



Question			Expected response	Max mark	Additional guidance
		(ii)	Scale diagram θ=15±2°	**2**	Trigonometry $\tan\theta = \dfrac{40}{150}$ 1 $\theta = 15°$ 1 Accept 10, 14·9, 14·93 Bearing 015 15° E of N

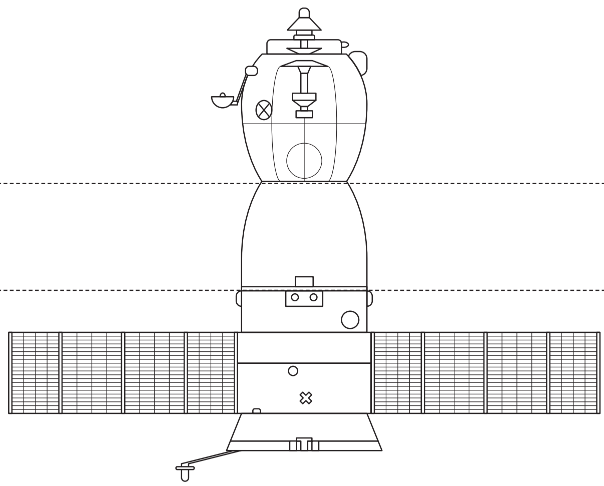


Question			Expected response	Max mark	Additional guidance
1.	(c)	(i)	$s =$ area under $v - t$ graph 1 $s = (10\times70)+(60\times5)+\frac{1}{2}(60\times45)$ 1 $s = 2350$ (m) 1 Runways X,Y and Z could have been used 1	**4**	
		(ii)	Aircraft has increased mass 1 so has reduced deceleration 1 OR Aircraft has increased kinetic energy 1 $E_w = Fd$ (so if F is constant d is greater) 1	**2**	

MARKS | DO NOT WRITE IN THIS MARGIN

2. The Soyuz Spacecraft is used to transport astronauts from the International Space Station (ISS) to Earth.

The spacecraft contains three parts.



Part	*Mass* (kg)
Orbital Module	1300
Descent Module (including astronauts)	2950
Instrumentation/ Propulsion Module	2900

(a) When the spacecraft leaves the ISS, the three parts are launched together. The propulsion module produces a force of 1430 N.

Calculate the acceleration of the spacecraft as it leaves the ISS. **4**

Space for working and answer

* S 8 5 7 7 5 0 1 0 9 *

Back to Table

2. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(b) During the flight, the Orbital Module and the Instrumentation/Propulsion Module are jettisoned. Instead of returning to Earth, they burn up in the atmosphere at a very high temperature.

Explain why these Modules burn up on re-entry into the atmosphere. **2**

(c) (i) After the Descent Module has re-entered the atmosphere, its speed is dramatically reduced. Four parachutes are used to slow the Module's rate of descent.

Explain, in terms of forces, how the parachutes reduce the speed of the Module. **2**

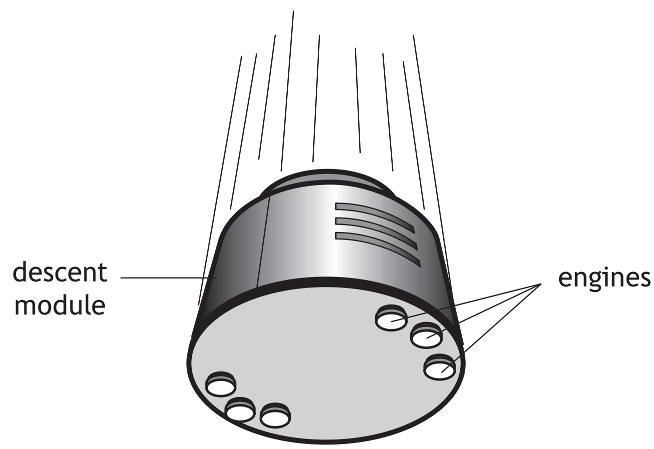
* S 8 5 7 7 5 0 1 1 0 *

Back to Table

2. (c) (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(ii) Just before touchdown, small engines fire on the bottom of the Module, slowing it down further. The work done by the engines is $8{\cdot}0 \times 10^4$ J over a distance of $5{\cdot}0$ m.



Calculate the force produced by the engines. **3**

Space for working and answer

2. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(d) The ISS orbits with an altitude of between $3{\cdot}30 \times 10^5$ m and $4{\cdot}35 \times 10^5$ m above the surface of the Earth.

(i) The orbital period T, in seconds, of the ISS can be calculated using the relationship

$$T = \frac{2\pi R}{v}$$

where v is the orbital speed in metres per second and R is the orbital radius in metres.

The orbital radius R is the sum of the radius of the Earth and the altitude above the surface of the Earth.

The radius of the Earth is $6{\cdot}4 \times 10^6$ m.

The orbital speed of the ISS can be taken to be $7{\cdot}7 \times 10^3$ m s^{-1}.

Calculate the orbital period of the ISS when it is orbiting at an altitude of $3{\cdot}30 \times 10^5$ m. **3**

Space for working and answer

(ii) State whether the orbital period of the ISS in its highest orbit will be less than, the same as, or greater than the orbital period calculated in part (d) (i). **1**

(iii) Explain, in terms of its horizontal velocity and weight, how the ISS remains in orbit around the Earth. **2**

* S 8 5 7 7 5 0 1 1 2 *

Question			Expected response		Max mark	Additional guidance
2.	(a)		$m = 1300 + 2950 + 2900$	1	**4**	
			$F = ma$	1		
			$1430 = (1300 + 2950 + 2900) \times a$	1		
			$a = 0 \cdot 2\ \text{m s}^{-2}$	1		
	(b)		Force of friction is created on the surface of the modules	1	**2**	
			causes heat to be produced	1		
	(c)	(i)	Upward force is increased (by parachutes)	1	**2**	
			producing an unbalanced force upwards	1		
		(ii)	$E_w = Fd$	1	**3**	Accept 20 000, 16 000·0, 16 000·00
			$80\,000 = F \times 5$	1		
			$F = 16\,000\ \text{N}$	1		
	(d)	(i)	$T = \dfrac{2\pi R}{v}$		**3**	1 mark for substitution of radius plus altitude Accept 5000, 5490, 5492
			$T = \dfrac{2 \times \pi \times (6 \cdot 4 \times 10^6 + 3 \cdot 30 \times 10^5)}{7 \cdot 7 \times 10^3}$	1,1		
			$T = 5500\ \text{s}$	1		
		(ii)	(Orbital period will be) greater		**1**	
		(iii)	The horizontal velocity of the ISS is large enough to ensure that it does not get closer to the Earth's surface (or equivalent statement)	1	**2**	
			The weight of the ISS is large enough to ensure that it does not move further away from the Earth's surface (or equivalent statement)	1		

MARKS | DO NOT WRITE IN THIS MARGIN

3. Read the passage below about the Dragonfish nebula, an interstellar cloud of dust and gases and star-forming region in space. Answer the questions that follow.

Dragonfish nebula conceals giant cluster of young stars

The Dragonfish nebula may contain the Milky Way's most massive cluster of young stars. Scientists from the University of Toronto found the first hint of the cluster in 2010 in the form of a big cloud of ionised gas 30 000 light years from Earth. They detected the gas from its microwave emissions, suspecting that radiation from massive stars nearby had ionised the gas.

Now the scientists have identified a cluster of 400 massive stars in the heart of the gas cloud using images from an infrared telescope. The cluster probably contains more stars which are too small and dim to detect.

The surrounding cloud of ionised gas is producing more microwaves than the clouds around other star clusters in our galaxy. This suggests that the Dragonfish nebula contains the brightest and most massive young cluster discovered so far, with a total mass of around 100 000 times the mass of the Sun.

(a) Name the galaxy mentioned in the passage. **1**

(b) Show that the Dragonfish nebula is approximately $2 \cdot 8 \times 10^{20}$ m away from Earth. **3**

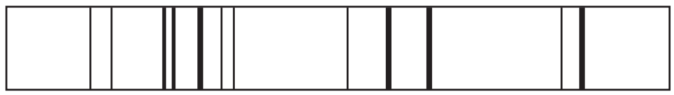
Space for working and answer

Back to Table

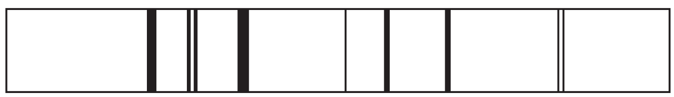
3. (continued)

(c) State how the frequency of microwave radiation compares to the frequency of infrared radiation. **1**

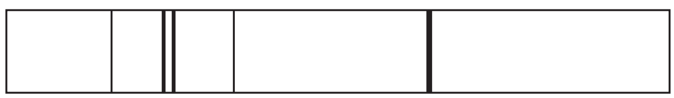
(d) A line spectrum from a nebula is shown below.



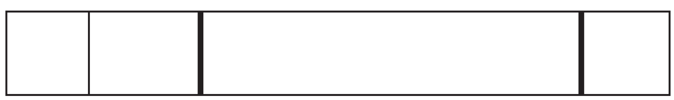
spectral lines from gases in the nebula



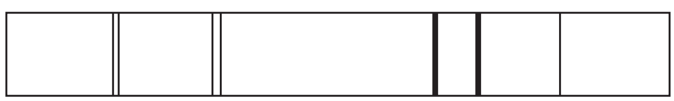
nitrogen



helium



hydrogen



krypton

Identify which of these elements are present in the nebula. **2**

Back to Table

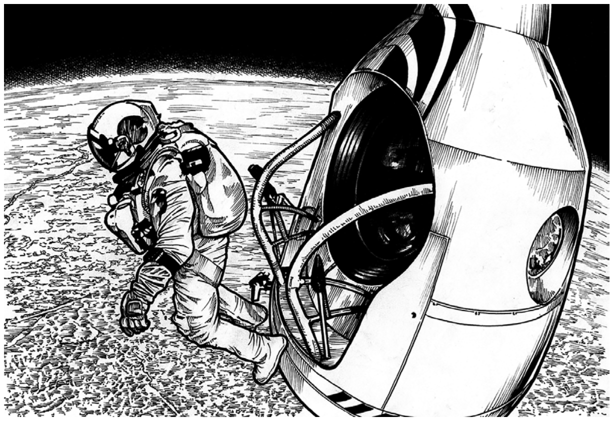
Question			Expected response	Max mark	Additional guidance
3.	(a)		Milky Way	**1**	
	(b)		$d = vt$ 1 $d = 30\,000 \times 3 \times 10^8 \times (365 \cdot 25 \times 24 \times 60 \times 60)$ 1,1 $d = 2 \cdot 8 \times 10^{20}$ m	**3**	**'Show' question** Accept 365, 365·24 If final answer not stated max 2 marks.
	(c)		(Microwave radiation has a) smaller (frequency than infra-red radiation)	**1**	
	(d)		Hydrogen 1 Helium 1	**2**	

MARKS | DO NOT WRITE IN THIS MARGIN

4. In October 2012, a skydiver jumped from a balloon at a height of 39 km above the surface of the Earth.

He became the first person to jump from this height.

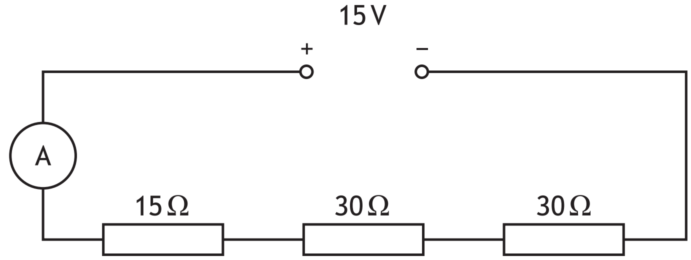
He also became the first human to fall at speeds higher than the speed of sound in air.



Using your knowledge of physics, comment on the challenges faced by the skydiver when making this jump. **3**

MARKS | DO NOT WRITE IN THIS MARGIN

5. (a) A student sets up the following circuit.



(i) Determine the total resistance in the circuit. **1**

(ii) Calculate the current in the circuit. **3**

Space for working and answer

(iii) Calculate the power dissipated in the 15 Ω resistor. **3**

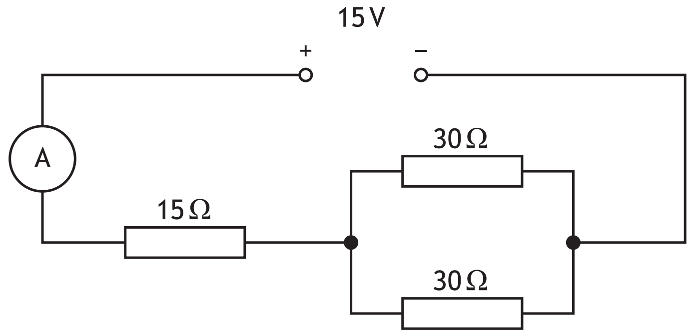
Space for working and answer

Back to Table

5. (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(b) The circuit is now rearranged as shown.



State how the power dissipated in the 15 Ω resistor compares to your answer in (a) (iii).

You must justify your answer. **3**

S857750117

Back to Table

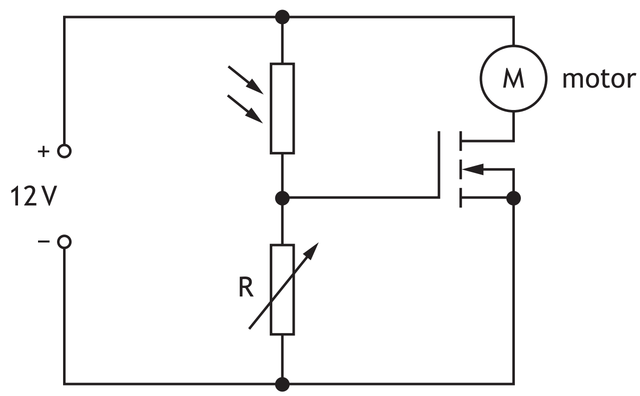
[Turn over

Question			Expected response		Max mark	Additional guidance
5.	(a)	(i)	$R_T = 75\ \Omega$		**1**	
		(ii)	$V = IR$	1	**3**	Or consistent with (a)(i)
			$15 = I \times 75$	1		Accept 0·2, 0·200, 0·2000
			$I = 0 \cdot 20$ A	1		
		(iii)	$P = I^2R$	1	**3**	Or consistent with (a)(ii)
			$P = 0 \cdot 20^2 \times 15$	1		Accept 0·6, 0·600, 0·6000
			$P = 0 \cdot 60$ W	1		
	(b)		(The power dissipated is) greater (than that in (a)(iii))	1	**3**	**'Must justify' question**
			The total resistance of the circuit is now less	1		
			The current in the circuit is now greater	1		

MARKS DO NOT WRITE IN THIS MARGIN

6. An office has an automatic window blind that closes when the light level outside gets too high.

The electronic circuit that operates the motor to close the blind is shown.



(a) The MOSFET switches on when the voltage across variable resistor R reaches 2·4 V.

(i) Explain how this circuit works to close the blind. **3**

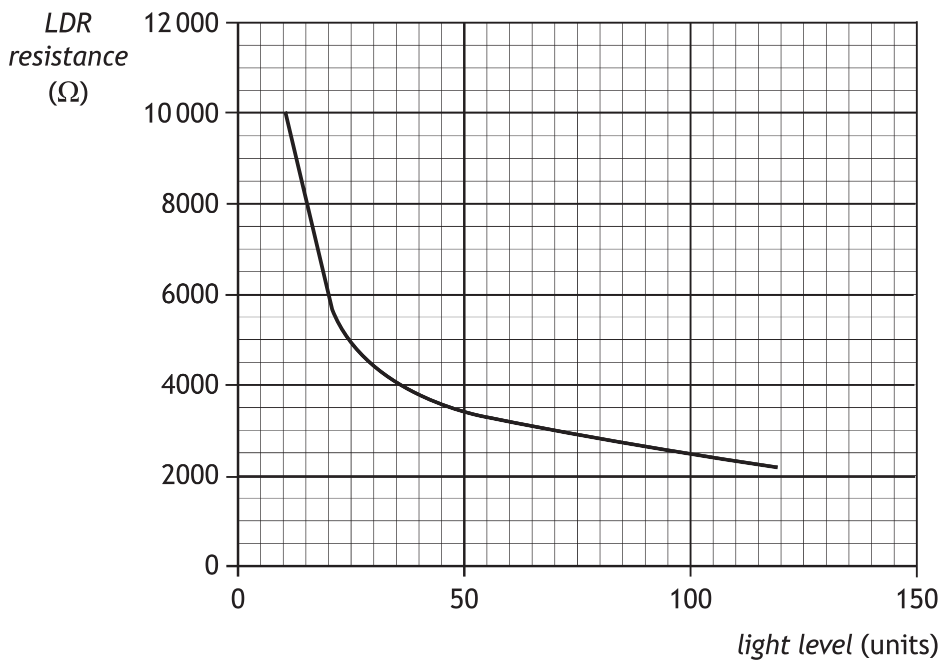
(ii) What is the purpose of the variable resistor R? **1**

Back to Table

6. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(b) The graph shows how the resistance of the LDR varies with light level.



(i) Determine the resistance of the LDR when the light level is 70 units. **1**

(ii) The variable resistor R is set at a resistance of 600 Ω.

Calculate the voltage across R when the light level is 70 units. **3**

Space for working and answer

(iii) State whether or not the blinds will close when the light level is 70 units.

Justify your answer. **2**

* S 8 5 7 7 5 0 1 1 9 *

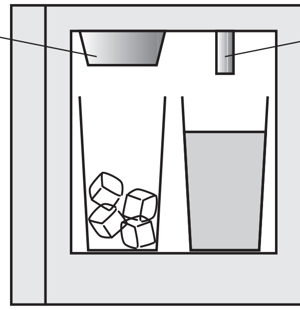
Back to Table

[Turn over

Question			Expected response	Max mark	Additional guidance
6.	(a)	(i)	Light level increases, LDR resistance decreases 1 LDR resistance decreases, voltage across R increases 1 Voltage across R increases, MOSFET switches the motor on 1	**3**	
		(ii)	The variable resistor controls the light level at which the motor operates the blind	**1**	
	(b)	(i)	3000±250 Ω	**1**	
		(ii)	$V_2 = \left(\frac{R_2}{R_1 + R_2}\right)V_s$ 1 $V_2 = \left(\frac{600}{600 + 3000}\right) \times 12$ 1 $V_2 = 2 \cdot 0\ \text{V}$ 1	**3**	Or consistent with (b)(i) Accept 2, 2·00, 2·000
		(iii)	The blinds will not close 1 The voltage across R is insufficient to switch the MOSFET on 1	**2**	

MARKS DO NOT WRITE IN THIS MARGIN

7. A fridge/freezer has water and ice dispensers as shown.



(a) Water of mass 0·100 kg flows into the freezer at 15·0 °C and is cooled to 0 °C.

Show that $6 \cdot 27 \times 10^3$ J of energy is removed when the water cools. **2**

Space for working and answer

(b) Calculate the energy released when 0·100 kg of water at 0 °C changes to 0·100 kg of ice at 0 °C. **3**

Space for working and answer

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7. (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(c) The fridge/freezer system removes heat energy at a rate of $115\,J\,s^{-1}$.

(i) Calculate the minimum time taken to produce 0·100 kg of ice from 0·100 kg of water at 15·0 °C. **4**

Space for working and answer

(ii) Explain why the actual time taken to make the ice will be longer than the time calculated in part (c) (i). **2**

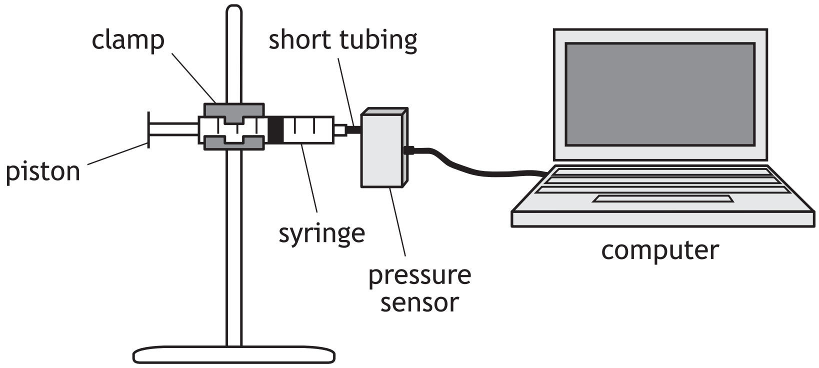
* S 8 5 7 7 5 0 1 2 1 *

Question			Expected response		Max mark	Additional guidance
7.	(a)		$E_h = cm\Delta T$	1	**2**	**'Show' question**
			$E_h = 4180 \times 0 \cdot 100 \times (15 \cdot 0 - 0)$	1		
			$E_h = 6270$ J			
	(b)		$E_h = ml$	1	**3**	Accept 3·3, 3·340, 3·3400
			$E_h = 0 \cdot 100 \times 3 \cdot 34 \times 10^5$	1		
			$E_h = 3 \cdot 34 \times 10^4$ J	1		
	(c)	(i)	$E_h = 6270 + 3 \cdot 34 \times 10^4$ (J)	1	**4**	Or consistent with (b) Accept 340, 345·0, 345·00
			$P = \frac{E_h}{t}$	1		
			$115 = \frac{(6270 + 3 \cdot 34 \times 10^4)}{t}$	1		
			$t = 345$ s	1		
		(ii)	Heat will be taken in from the surroundings	1	**2**	
			so the system will have additional heat to remove	1		

Back to Table

MARKS DO NOT WRITE IN THIS MARGIN

8. A student carries out an experiment to investigate the relationship between the pressure and volume of a fixed mass of gas using the apparatus shown.



The pressure p of the gas is recorded using a pressure sensor connected to a computer. The volume V of the gas in the syringe is also recorded. The student pushes the piston to alter the volume and a series of readings is taken.

The temperature of the gas is constant during the experiment.

The results are shown.

p (kPa)	100	125	152	185	200
V (cm^3)	50	40	33	27	25
$1/V$ (cm^{-3})	0·020	0·025	0·030	0·037	0·040

(a) (i) Using the square-ruled paper on *page 23*, draw a graph of p against $1/V$.

You must start the scale on each axis from 0. **3**

(Additional square-ruled paper, if required, can be found on *page 32*.)

(ii) Explain how the graph confirms that pressure is directly proportional to 1/volume. **1**

* S 8 5 7 7 5 0 1 2 2 *

MARKS | DO NOT WRITE IN THIS MARGIN

8. (continued)

(b) Calculate the pressure of the gas in the syringe when its volume is $8 \cdot 0\,\text{cm}^3$. **3**

Space for working and answer

(c) Using the kinetic model, explain the increase in the pressure of the gas in the syringe as its volume decreases. **2**

(d) (i) When carrying out the experiment, the student clamped the syringe rather than holding it in their hand.

Explain why this is better experimental practice. **2**

(ii) A second student suggests that replacing the short tubing between the syringe and the pressure sensor with one of longer length would improve the experiment.

Explain why this student's suggestion is incorrect. **2**

* S 8 5 7 7 5 0 1 2 4 *

Question			Expected response	Max mark	Additional guidance
8.	(a)	(i)	Axes labelled with units 1 Axes scaled linearly 1 Data points accurately plotted with line of best fit 1	**3**	
		(ii)	The line of best fit is a straight line which passes through the origin	**1**	
	(b)		$p_1V_1 = p_2V_2$ 1 $125 \times 40 = p_2 \times 8 \cdot 0$ 1 $p_2 = 630\ \text{kPa}$ 1	**3**	Accept 600, 625, 625·0 Accept any given data points or points selected from graph
	(c)		As volume decreases, the particles of gas will strike the piston of the syringe more often 1 Since $P = \frac{F}{A}$, this results in an increased pressure 1	**2**	
	(d)	(i)	Using a clamp will prevent heat from the student's hand increasing the temperature of the gas in the syringe 1 If the temperature of the gas in the syringe is not constant, the experiment would not be valid 1	**2**	Or equivalent statements
		(ii)	The suggestion is incorrect because the volume of air in the tubing is not being read from the scale on the syringe 1 A longer length of tubing would increase the (systematic) uncertainty in the experiment 1	**2**	Or equivalent statements

MARKS DO NOT WRITE IN THIS MARGIN

9. A mountain climber carries a small, portable 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.

(a) One satellite sends a radio signal that is received by the device 0·0047 s after transmission.

(i) State the speed of the radio signal. **1**

(ii) Calculate the distance between this satellite and the climber. **3**

Space for working and answer

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

The frequency of the signal is 1620 MHz.

Calculate the wavelength of this signal. **3**

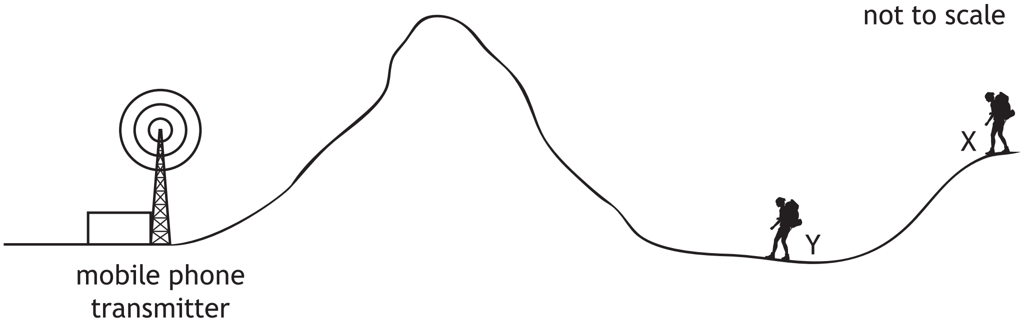
Space for working and answer

* S 8 5 7 7 5 0 1 2 5 *

9. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(c)



The climber also carries a mobile phone. The climber notices that the phone receives a signal at X but not at Y.

Explain why the phone receives a signal at X but not at Y. **2**

Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	$3{\cdot}00\times10^{8}\ \text{m s}^{-1}$	**1**	Accept 3, 3·0
		(ii)	$d = vt$ 1 $d = 3\cdot00\times10^{8}\times0\cdot0047$ 1 $d = 1\cdot4\times10^{6}\ \text{m}$ 1	**3**	Or consistent with (a)(i) Accept 1, 1·41, 1·410
	(b)		$v = f\lambda$ 1 $3\cdot00\times10^{8} = 1620\times10^{6}\times\lambda$ 1 $\lambda = 0\cdot185\ \text{m}$ 1	**3**	Or consistent with (a)(i) Accept 0·19, 0·1852, 0·18519
	(c)		The waves from the transmitter will diffract over the hill to reach X 1 but will not diffract enough to reach Y 1	**2**	

MARKS | DO NOT WRITE IN THIS MARGIN

10. A physics textbook contains the following statement.

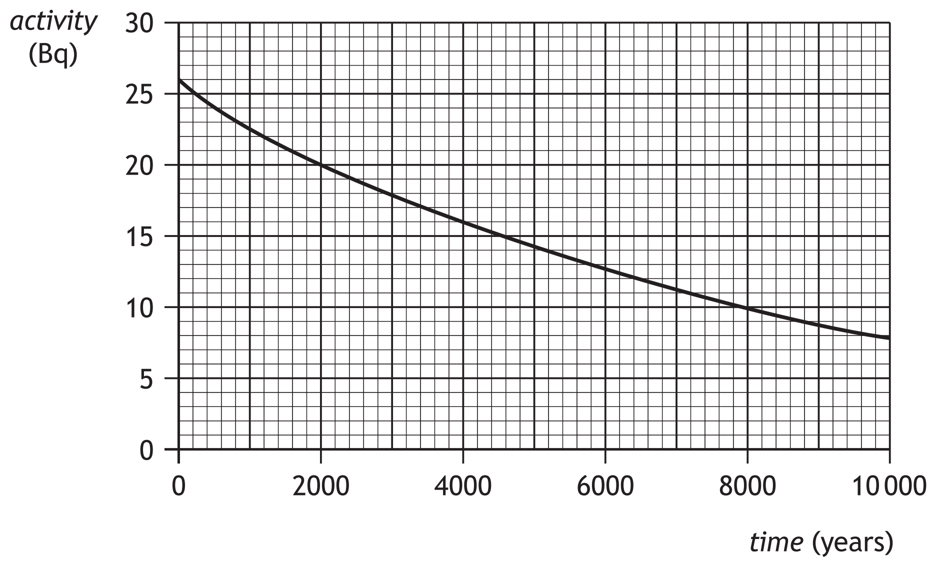
'Electromagnetic waves can be sent out like ripples on a pond.'

Using your knowledge of physics, comment on the similarities and/or differences between electromagnetic waves and the ripples on a pond. **3**

Back to Table

11. Trees continually absorb carbon-14 when they are alive. When a tree dies the carbon-14 contained in its wood is not replaced. Carbon-14 is radioactive and decays by beta emission.

(a) Following the tree's death, the activity of the carbon-14 within a **25 mg** sample of its wood changes as shown.



(i) Use the graph to determine the half-life of carbon-14. **1**

(ii) Calculate the time taken for the activity of this sample of carbon-14 to fall to 6·5 Bq. **3**

Space for working and answer

Back to Table

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

(iii) During an archaeological dig, a 125 mg sample of the same type of wood was obtained. The activity of this sample was 40 Bq.

Estimate the age of this sample. **3**

Space for working and answer

(b) Explain why this method could not be used to estimate the age of a tree that died 100 years ago. **1**

* S 8 5 7 7 5 0 1 2 9 *

[Turn over

Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	5800±100 years	**1**	
		(ii)	$26 \rightarrow 13 \rightarrow 6 \cdot 5$ Number of half-lives $= 2$ 1 $t = 2 \times 5800$ 1 $t = 10\,600$ years 1	**3**	Or consistent with (a)(i)
		(iii)	$\frac{125}{25} = 5$ 1 Activity per 25 g $= \frac{40}{5} = 8$ (Bq) 1 From graph, age = 9700±100 years 1	**3**	
	(b)		The activity (of a sample from the tree) would not have reduced significantly/ measurably in 100 years	**1**	

MARKS DO NOT WRITE IN THIS MARGIN

12. A worker in the radiation industry uses a radioactive source to investigate the effect of gamma rays on biological tissue.

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

(b) In one experiment, a biological tissue sample of mass 0·10 kg receives an absorbed dose of 50 μGy.

Calculate the energy absorbed by the tissue. **3**

Space for working and answer

(c) The radioactive source must be stored in a lead-lined container.

Explain why a lead-lined container should be used. **1**

MARKS DO NOT WRITE IN THIS MARGIN

12. (continued)

(d) State the annual effective dose limit for the radiation worker. **1**

[END OF SPECIMEN QUESTION PAPER]

Question			Expected response	Max mark	Additional guidance
12.	(a)		High frequency (or short wavelength) electromagnetic radiation	**1**	
	(b)		$D = \frac{E}{m}$ 1 $50\times10^{-6} = \frac{E}{0{\cdot}10}$ 1 $E = 5{\cdot}0\times10^{-6}$ J 1	**3**	Accept 5, 5·00, 5·000
	(c)		Lead can absorb (some of) the gamma rays	**1**	
	(d)		20 mSv	**1**	

[END OF SPECIMEN MARKING INSTRUCTIONS]

N5 National Qualifications 2018

X857/75/02

Physics Section 1 — Questions

TUESDAY, 8 MAY

1:00 PM – 3:30 PM

Instructions for the completion of Section 1 are given on *page 02* of your question and answer booklet X857/75/01.

Record your answers on the answer grid on *page 03* of your question and answer booklet.

Reference may be made to the Data Sheet on *page 02* of this booklet and to the Relationships Sheet X857/75/11.

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

X8577502

A/HTP

Back to Table

DATA SHEET

Speed of light in materials

Material	*Speed* in m s^{-1}
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	$2{\cdot}3 \times 10^8$

Gravitational field strengths

	Gravitational field strength on the surface in N kg^{-1}
Earth	9·8
Jupiter	23
Mars	3·7
Mercury	3·7
Moon	1·6
Neptune	11
Saturn	9·0
Sun	270
Uranus	8·7
Venus	8·9

Specific latent heat of fusion of materials

Material	*Specific latent heat of fusion* in J kg^{-1}
Alcohol	$0{\cdot}99 \times 10^5$
Aluminium	$3{\cdot}95 \times 10^5$
Carbon Dioxide	$1{\cdot}80 \times 10^5$
Copper	$2{\cdot}05 \times 10^5$
Iron	$2{\cdot}67 \times 10^5$
Lead	$0{\cdot}25 \times 10^5$
Water	$3{\cdot}34 \times 10^5$

Specific latent heat of vaporisation of materials

Material	*Specific latent heat of vaporisation* in J kg^{-1}
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	$22{\cdot}6 \times 10^5$

Speed of sound in materials

Material	*Speed* in m s^{-1}
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Specific heat capacity of materials

Material	*Specific heat capacity* in J kg^{-1} °C^{-1}
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Ice	2100
Iron	480
Lead	128
Oil	2130
Water	4180

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
Iron	1537	2737

Radiation weighting factors

Type of radiation	*Radiation weighting factor*
alpha	20
beta	1
fast neutrons	10
gamma	1
slow neutrons	3
X-rays	1

Back to Table

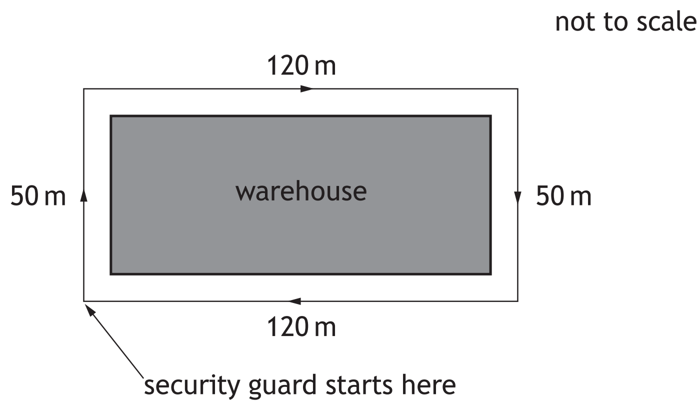
SECTION 1

Attempt ALL questions

1. Which of the following is a scalar quantity?

A velocity
B displacement
C acceleration
D force
E speed

2. A security guard starts at the corner of a warehouse, walks round the warehouse as shown and arrives back at the same corner.



Which row in the table shows the total distance walked by the security guard and the magnitude of the displacement of the security guard from the start to the end of the walk?

	Total distance (m)	*Displacement* (m)
A	0	0
B	0	340
C	170	130
D	340	0
E	340	340

[Turn over

3. A ball is thrown vertically upwards. The ball reaches its maximum height.

Which of the following describes the forces acting on the ball at this instant?

A There is no vertical force acting on the ball.

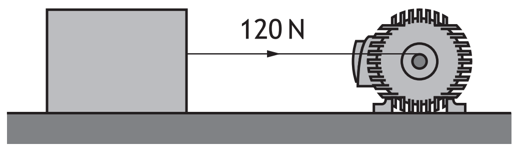
B There is only a horizontal force acting on the ball.

C There is an upward force acting on the ball.

D The forces acting on the ball are balanced.

E There is only a downward force acting on the ball.

4. A motor is used to apply a force of 120 N to a box of mass 30 kg.



The box moves at a constant speed across a horizontal surface.

The box moves a distance of 25 m in a time of 5·0 s.

Which row in the table shows the work done on the box and the minimum output power of the motor?

	Work done (J)	*Minimum output power* (W)
A	600	120
B	600	3000
C	3000	600
D	3000	15 000
E	3600	720

5. A galaxy is a collection of

A stars

B satellites

C moons

D planets

E asteroids.

6. The communications satellite Iridium-124 has a period of 97 minutes and an orbital height of 630 km.

The geostationary satellite Astra-5B has a period of 1440 minutes and an orbital height of 36 000 km.

A satellite with an orbital height of 23 000 km has a period of

A 62 minutes

B 97 minutes

C 835 minutes

D 1440 minutes

E 2250 minutes.

7. Far out in space, the rocket engine of a space probe is switched on for a short time causing it to accelerate.

When the engine is then switched off, the probe will

A slow down until it stops

B follow a curved path

C continue to accelerate

D move at a constant speed

E change direction.

8. A spacecraft lands on a distant planet.

The gravitational field strength on this planet is $14\,\mathrm{N\,kg^{-1}}$.

Which row in the table shows how the mass and weight of the spacecraft on this planet compares with the mass and weight of the spacecraft on Earth?

	Mass on planet	*Weight on planet*
A	same as on Earth	greater than on Earth
B	greater than on Earth	greater than on Earth
C	same as on Earth	same as on Earth
D	greater than on Earth	same as on Earth
E	same as on Earth	less than on Earth

[Turn over

9. The distance from the Sun to the star Sirius is 8·6 light years.

This distance is equivalent to

A $2{\cdot}2 \times 10^{14}$ m

B $1{\cdot}4 \times 10^{15}$ m

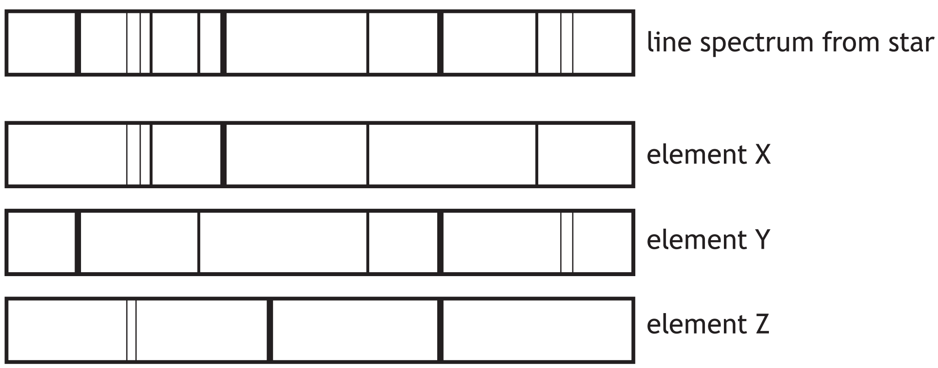
C $3{\cdot}4 \times 10^{15}$ m

D $8{\cdot}1 \times 10^{16}$ m

E $9{\cdot}5 \times 10^{16}$ m.

10. Light from a star is split into a line spectrum of different colours.

The line spectrum from the star is shown, along with the line spectra of the elements X, Y and Z.



The elements present in this star are

A X only

B Y only

C X and Y only

D X and Z only

E X, Y and Z.

11. A student makes the following statements about a.c. and d.c. circuits.

I In an a.c. circuit the direction of the current changes regularly.

II In a d.c. circuit negative charges flow in one direction only.

III In an a.c. circuit the size of the current varies with time.

Which of these statements is/are correct?

A I only

B II only

C I and II only

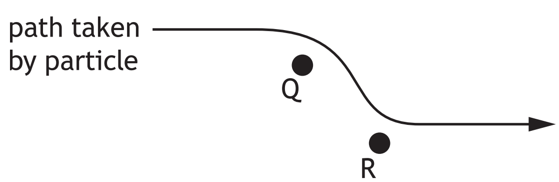
D I and III only

E I, II and III

12. An electric field exists around two point charges Q and R.

The diagram shows the path taken by a charged particle as it travels through the field.

The motion of the particle is as shown.

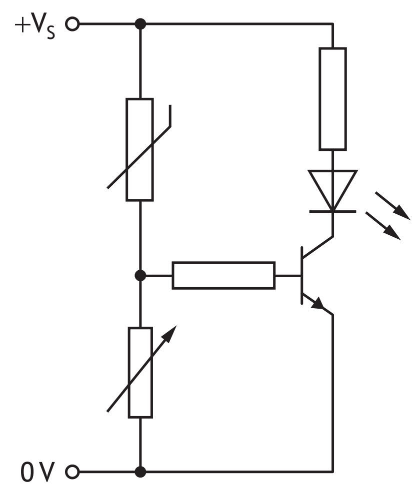


Which row in the table identifies the charge on the particle, the charge on Q and the charge on R?

	Charge on particle	*Charge on Q*	*Charge on R*
A	positive	negative	negative
B	negative	negative	negative
C	negative	positive	positive
D	positive	negative	positive
E	positive	positive	negative

[Turn over

13. A transistor switching circuit is set up as shown.



The variable resistor is adjusted until the LED switches off.

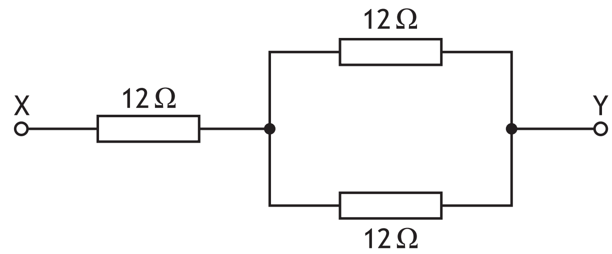
The temperature of the thermistor is now increased.

The resistance of the thermistor decreases as the temperature increases.

Which row in the table describes the effect of this change on the voltage across the thermistor, the voltage across the variable resistor, and whether the LED stays off or switches on?

	Voltage across the thermistor	*Voltage across the variable resistor*	*LED*
A	decreases	increases	switches on
B	decreases	decreases	switches on
C	decreases	decreases	stays off
D	increases	decreases	stays off
E	increases	increases	switches on

14. Three resistors are connected as shown.



The resistance between X and Y is

A 4 Ω

B 6 Ω

C 18 Ω

D 24 Ω

E 36 Ω.

15. The filament of a lamp has a resistance of 4·0 Ω.

The lamp is connected to a 12 V supply.

The power developed by the lamp is

A 3 W

B 36 W

C 48 W

D 96 W

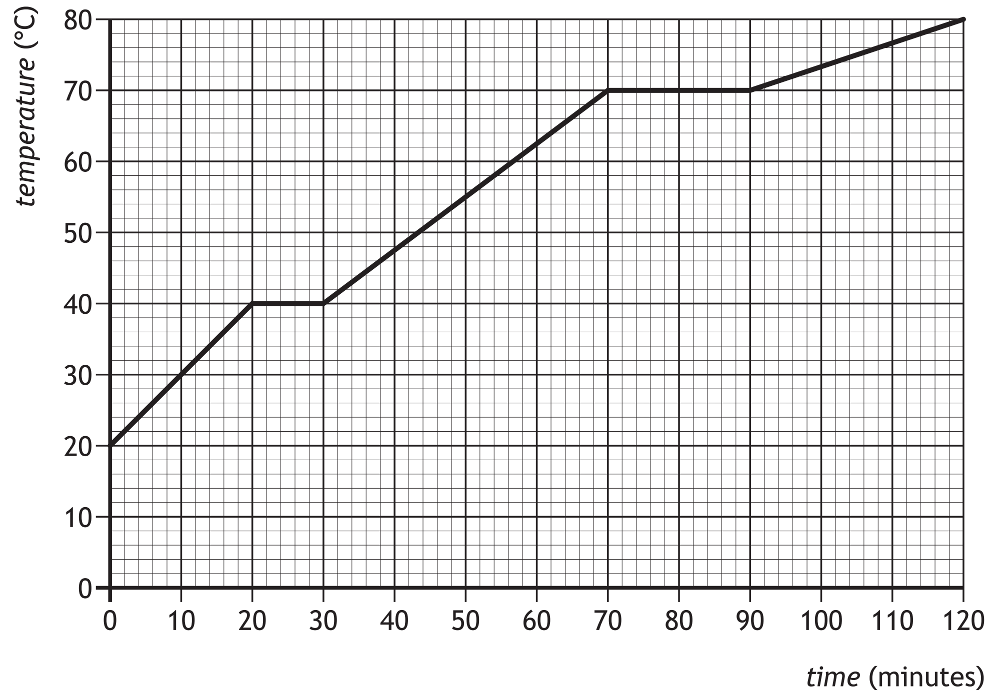
E 576 W.

[Turn over

16. A block of wax is initially in the solid state.

The block of wax is then heated.

The graph shows how the temperature of the wax changes with time.



The melting point of the wax is

A 0 °C

B 20 °C

C 40 °C

D 70 °C

E 80 °C.

17. The pressure of the air outside an aircraft is $0{\cdot}40 \times 10^5$ Pa.

The air pressure inside the aircraft cabin is $1{\cdot}0 \times 10^5$ Pa.

The area of an external cabin door is $2{\cdot}0\,m^2$.

The outward force on the door due to the pressure difference is

A $0{\cdot}30 \times 10^5$ N

B $0{\cdot}70 \times 10^5$ N

C $1{\cdot}2 \times 10^5$ N

D $2{\cdot}0 \times 10^5$ N

E $2{\cdot}8 \times 10^5$ N.

18. A solid at a temperature of –20 °C is heated until it becomes a liquid at 70 °C.

The temperature change in kelvin is

A 50 K

B 90 K

C 343 K

D 363 K

E 596 K.

19. A sealed bicycle pump contains $4{\cdot}0 \times 10^{-5}\,m^3$ of air at a pressure of $1{\cdot}2 \times 10^5\,Pa$.

The piston of the pump is pushed in until the volume of air in the pump is reduced to $0{\cdot}80 \times 10^{-5}\,m^3$.

During this time the temperature of the air in the pump remains constant.

The pressure of the air in the pump is now

A $2{\cdot}4 \times 10^4\,Pa$

B $1{\cdot}2 \times 10^5\,Pa$

C $1{\cdot}5 \times 10^5\,Pa$

D $4{\cdot}4 \times 10^5\,Pa$

E $6{\cdot}0 \times 10^5\,Pa$.

20. A student makes the following statements about diffraction.

I Diffraction occurs when waves pass from one medium into another.

II Waves with a longer wavelength diffract more than waves with a shorter wavelength.

III Microwaves diffract more than radio waves.

Which of these statements is/are correct?

A I only

B II only

C I and II only

D II and III only

E I, II and III

[Turn over

21. The diagram shows part of the electromagnetic spectrum arranged in order of increasing wavelength.

increasing wavelength $\longrightarrow$

gamma rays	R	ultraviolet	visible light

Which row in the table identifies radiation R and describes its frequency?

	Radiation R	*Frequency of radiation R*
A	X-rays	higher frequency than visible light
B	microwaves	lower frequency than visible light
C	X-rays	lower frequency than visible light
D	infrared	lower frequency than visible light
E	microwaves	higher frequency than visible light

22. The energy of a water wave can be calculated using

$$E = \frac{\rho g A^2}{2}$$

where: E is the energy of the wave in J

ρ is the density of the water in kg m^{-3}

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

A is the amplitude of the wave in m.

A wave out at sea has an amplitude of 3·5 m.

The density of the sea water is $1{\cdot}02 \times 10^3$ kg m^{-3}.

The energy of the wave is

A $6{\cdot}2 \times 10^3$ J

B $1{\cdot}7 \times 10^4$ J

C $6{\cdot}1 \times 10^4$ J

D $1{\cdot}2 \times 10^5$ J

E $6{\cdot}1 \times 10^8$ J.

23. A sample of tissue receives an equivalent dose rate of 0·40 mSv h^{-1} from a source of alpha radiation.

The equivalent dose received by the sample in 30 minutes is

A 0·20 mSv

B 0·80 mSv

C 4·0 mSv

D 12 mSv

E 720 mSv.

24. A radioactive source has an initial activity of 200 kBq. After 12 days the activity of the source is 25 kBq.

The half-life of the source is

A 3 days

B 4 days

C 8 days

D 36 days

E 48 days.

25. In the following passage some words have been replaced by the letters *X*, *Y* and *Z*.

During a nuclear ...X... reaction two nuclei of smaller mass number combine to produce a nucleus of larger mass number. These reactions take place at very ...Y... temperatures and are important because they can release ...Z...

Which row in the table shows the missing words?

	X	*Y*	*Z*
A	fusion	low	electrons
B	fusion	high	energy
C	fission	high	protons
D	fission	low	energy
E	fusion	high	electrons

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET]

Marking instructions for each question

Section 1

Question	Answer	Mark
1.	E	1
2.	D	1
3.	E	1
4.	C	1
5.	A	1
6.	C	1
7.	D	1
8.	A	1
9.	D	1
10.	C	1
11.	E	1
12.	D	1
13.	A	1
14.	C	1
15.	B	1
16.	C	1
17.	C	1
18.	B	1
19.	E	1
20.	B	1
21.	A	1
22.	C	1
23.	A	1
24.	B	1
25.	B	1

Back to Table

FOR OFFICIAL USE

N5

National Qualifications 2018

Mark

X857/75/01

Physics
Section 1 — Answer Grid and Section 2

TUESDAY, 8 MAY

1:00 PM – 3:30 PM

X85775 01

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 — 135

SECTION 1 — 25 marks

Attempt ALL questions.

Instructions for 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 X857/75/02 and to the Relationships Sheet X857/75/11.

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. 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.

X8577501 01

A/HTP

Back to Table

DO NOT WRITE IN THIS MARGIN

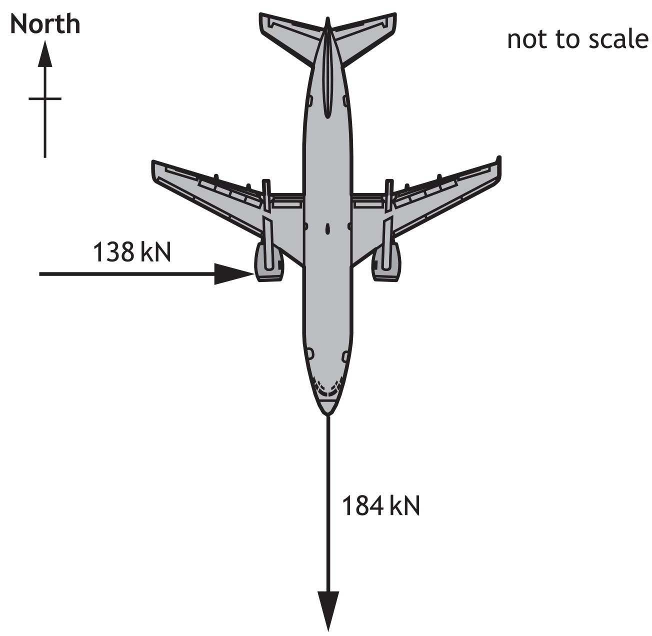
SECTION 2 — 110 marks

Attempt ALL questions

1. A passenger aircraft is flying horizontally.

(a) At one point during the flight the aircraft engines produce an unbalanced force of 184 kN due south (180).

At this point the aircraft also experiences a crosswind. The force of the crosswind on the aircraft is 138 kN due east (090).



X857750106

1. (a) (continued) MARKS DO NOT WRITE IN THIS MARGIN

(i) By scale diagram, or otherwise, determine:

(A) the magnitude of the resultant force acting on the aircraft; **2**

Space for working and answer

(B) the direction of the resultant force acting on the aircraft. **2**

Space for working and answer

[Turn over

X857750107

Back to Table

1. (a) (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(ii) The mass of the aircraft is $6{\cdot}8 \times 10^4$ kg.

Calculate the magnitude of the acceleration of the aircraft at this point. **3**

Space for working and answer

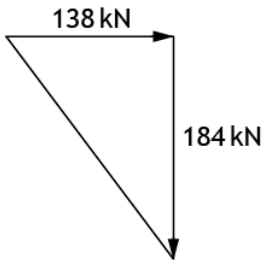
(b) During the flight the aircraft uses fuel.

Explain why the pressure exerted by the tyres of the aircraft on the runway after the flight is less than the pressure exerted by the tyres on the runway before the flight. **2**

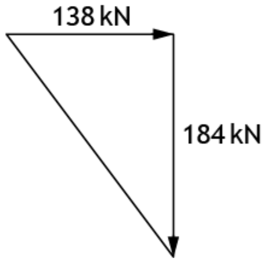
Back to Table

Back to Table

Section 2

Question			Expected response	Max mark	Additional guidance
1.	(a)	(i) (A)	**Using scale diagram:**  Vectors to scale **(1)** Resultant = 230 kN **(1)** (allow ±10 kN) **Using Pythagoras:** $\text{Resultant}^2 = 184^2 + 138^2$ **(1)** Resultant = 230 kN **(1)**	**2**	Regardless of method, if a candidate shows a vector diagram (or a representation of a vector diagram eg a triangle with no arrows) and the vectors have been added incorrectly, eg head-to-head then MAX (1). Ignore any direction stated in the final answer in this part. Can obtain first mark for scale diagram method from suitable diagram in part (a) (i) (B) if not drawn in this part.

Back to Table

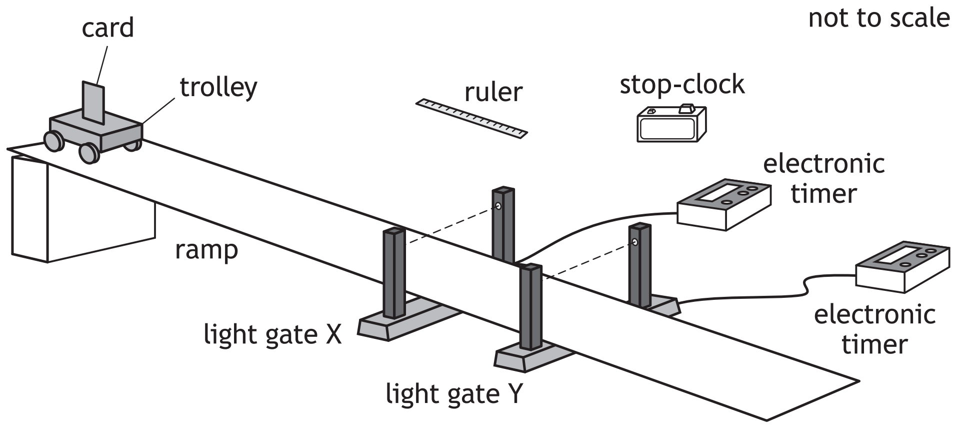
Question			Expected response	Max mark	Additional guidance
1.	(a)	(i) (B)	**Using scale diagram:**  Angles correct **(1)** direction = 143 **(1)** (allow ±2° tolerance) **Using trigonometry:** $tan\,\theta = \frac{184}{138}$ **(1)** $(\theta = 53{\cdot}1°)$ direction = 143 **(1)**	2	Or use of the magnitude of the resultant consistent with (a)(i) (A) Regardless of method, if a candidate (re)draws a vector diagram (or a representation of a vector diagram eg a triangle with no arrows) in this part and the vectors have been added incorrectly, eg head-to-head then MAX (1). Alternative method: $tan\,\theta = \frac{138}{184}$ **(1)** $(\theta = 36{\cdot}9°)$ direction = 143 **(1)** Accept: 53° S of E 37° E of S Ignore the degree symbol if direction is stated as a bearing. Can also do with other trig functions, eg $\sin\theta = \frac{184}{230}$ or $\cos\theta = \frac{138}{230}$ Can obtain first mark for scale diagram method from suitable diagram in part (a) (i) (A) if not drawn in this part. Accept: 53° S of E 53·1° S of E 143 53.13° S of E 143·1 53·130° S of E 143·13
		(ii)	$F = ma$ **(1)** $230\,000 = 6{\cdot}8 \times 10^4 \times a$ **(1)** $a = 3{\cdot}4\ \text{m s}^{-2}$ **(1)**	3	Or resultant consistent with (a)(i)(A) Ignore any direction stated. Accept 1-4 sig fig: $3\ \text{m s}^{-2}$ $3{\cdot}4\ \text{m s}^{-2}$ $3{\cdot}38\ \text{m s}^{-2}$ $3{\cdot}382\ \text{m s}^{-2}$

Question			Expected response	Max mark	Additional guidance
1.	(b)		Mass/weight/(downward) force is less. **(1)** pressure is force/weight per unit area. **(1)**	**2**	Second mark is dependent upon the first. Accept $p = \frac{F}{A}$ for second mark. Accept: 'lighter'

MARKS | DO NOT WRITE IN THIS MARGIN

2. Two students are investigating the acceleration of a trolley down a ramp.

(a) The first student uses the apparatus shown to determine the acceleration of the trolley.



Some of the measurements made by the student are shown.

Time for the card to pass through light gate Y	0·098 s
Distance between light gate X and light gate Y	0·22 m
Length of the card	0·045 m
Time for trolley to pass between light gate X and light gate Y	0·56 s

The student determines the instantaneous speed of the trolley at light gate X to be 0·32 m s^{-1}.

(i) State the **additional** measurement made by the student to determine the instantaneous speed of the trolley at light gate X. **1**

2. (a) (continued) **MARKS** DO NOT WRITE IN THIS MARGIN

(ii) Show that the instantaneous speed of the trolley at light gate Y is $0{\cdot}46\,\mathrm{m\,s^{-1}}$. **2**

Space for working and answer

(iii) Determine the acceleration of the trolley down the ramp. **3**

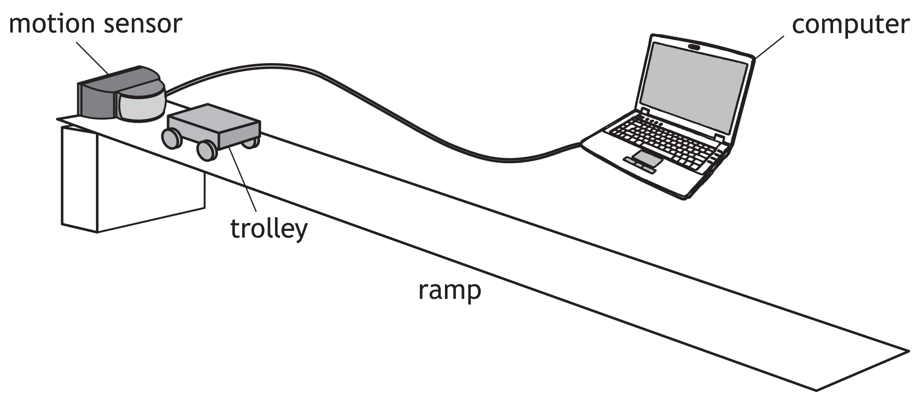
Space for working and answer

[Turn over

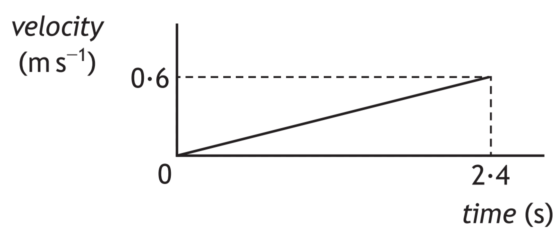
X857750111

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

(b) The second student uses a motion sensor and a computer to determine the acceleration of the trolley.



The student releases the trolley. The computer displays the velocity-time graph for the motion of the trolley as it rolls down the ramp, as shown.



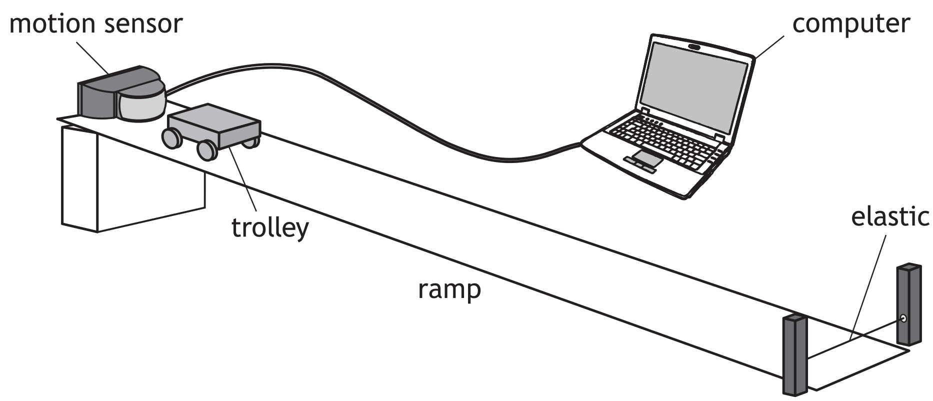
Determine the distance travelled by the trolley in the first 2·4 s after its release. **3**

Space for working and answer

2. (continued)

MARKS DO NOT WRITE IN THIS MARGIN

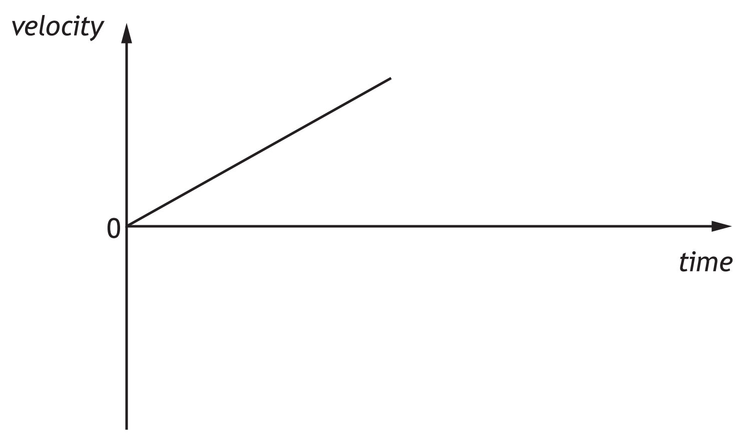
(c) In a further experiment the second student places a piece of elastic across the bottom of the ramp as shown.



The student again releases the trolley. The trolley rolls down the ramp and rebounds from the elastic to move back up the ramp.

Using the axes provided, complete the velocity-time graph for the motion of the trolley from the moment it contacts the elastic, until it reaches its maximum height back up the ramp. **2**

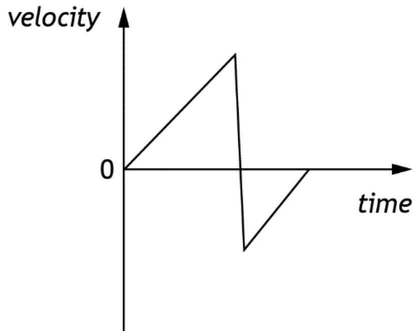
Numerical values are not required on either axis.



(An additional diagram, if required, can be found on *page 43*.)

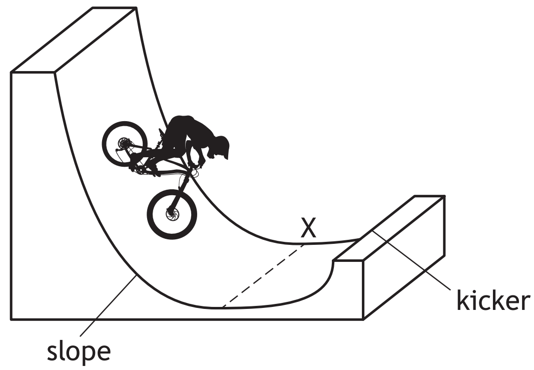
[Turn over

Question			Expected response	Max mark	Additional guidance
2.	(a)	(i)	Time for card to cut/pass through light gate X **(1)**	**1**	Do not accept: • 'time from electronic timer' alone • 'time from light gate X' • 'time for trolley to go down ramp' • 'time for trolley to cut beam' – it is the card that cuts the beam Apply +/- rule for surplus answers. However, ignore mention of measurement of 'length of card'.
		(ii)	$v = \frac{length\ of\ card}{time\ for\ card\ to\ cut\ beam}$ **(1)** $v = \frac{0{\cdot}045}{0{\cdot}098}$ **(1)** $v = 0{\cdot}46\ \text{m s}^{-1}$	**2**	**'Show' question** Must start with the correct relationship or (0). Final answer of $0{\cdot}46\ \text{m s}^{-1}$, including unit, must be shown, otherwise MAX (1). Accept: $v = \frac{d}{t}$ or $v = \frac{s}{t}$ or $\bar{v} = \frac{d}{t}$ or $\bar{v} = \frac{s}{t}$ if substitutions are correct.
		(iii)	$a = \frac{v - u}{t}$ **(1)** $a = \frac{0{\cdot}46 - 0{\cdot}32}{0{\cdot}56}$ **(1)** $a = 0{\cdot}25\ \text{m s}^{-2}$ **(1)**	**3**	Accept: $a = \frac{\Delta v}{t}$ or $v = u + at$ Do not accept: $a = \frac{v}{t}$ or $v = at$ Accept 1-4 sig fig: $0{\cdot}3\ \text{m s}^{-2}$ $0{\cdot}25\ \text{m s}^{-2}$ $0{\cdot}250\ \text{m s}^{-2}$ $0{\cdot}2500\ \text{m s}^{-2}$
	(b)		$distance = area\ under\ graph$ **(1)** $= \frac{1}{2} \times 2{\cdot}4 \times 0{\cdot}60$ **(1)** $= 0{\cdot}72$ m **(1)**	**3**	Accept 1-4 sig fig: 0·7 m 0·72 m 0·720 m 0·7200 m Accept: $s = \bar{v}t$ or $d = \bar{v}t$ $s = vt$ or $d = vt$, provided substitution of average velocity/speed is correct.

Question			Expected response	Max mark	Additional guidance
2.	(c)		 Line with negative gradient to cross time axis to negative value of velocity **(1)** Line with positive gradient to return to intercept time axis **(1)**	**2**	First mark can be awarded for vertical line crossing time axis. Ignore any numerical values. Line should not continue beyond the time when the trolley reaches its maximum height.

MARKS | DO NOT WRITE IN THIS MARGIN

3. During a BMX competition, a cyclist freewheels down a slope and up a 'kicker' to complete a vertical jump.



The cyclist and bike have a combined mass of 75 kg.

At point X the cyclist and bike have a speed of $8{\cdot}0\,\text{m}\,\text{s}^{-1}$.

(a) Calculate the kinetic energy of the cyclist and bike at point X. **3**

Space for working and answer

(b) (i) Calculate the maximum height of the jump above point X. **3**

Space for working and answer

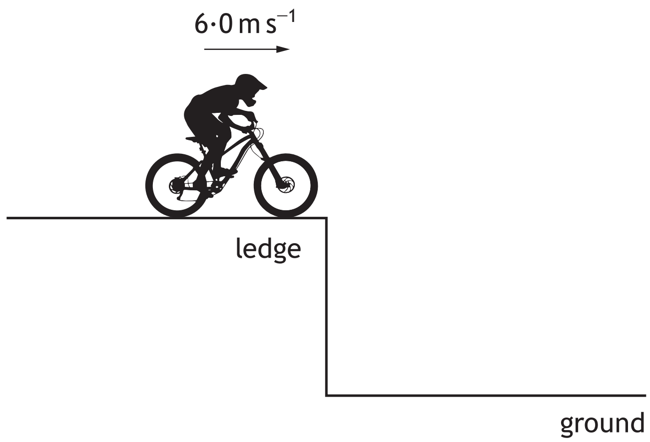
(ii) Explain why the actual height of the jump above point X would be less than the height calculated in (b) (i). **1**

X857750114

3. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(c) During another part of the competition, the cyclist and bike travel horizontally at $6{\cdot}0\,\text{m}\,\text{s}^{-1}$ off a ledge as shown.



(i) On the diagram above, sketch the path taken by the cyclist and bike between leaving the ledge and reaching the ground. **1**

(An additional diagram, if required, can be found on *page 43*.)

(ii) The cyclist and bike reach the ground 0·40 s after leaving the ledge.

Calculate the vertical velocity of the cyclist and bike as they reach the ground.

The effects of air resistance can be ignored. **3**

Space for working and answer

[Turn over

X857750115

Question			Expected response	Max mark	Additional guidance
3.	(a)		$E_k = ½ mv^2$ **(1)** $E_k = ½ \times 75 \times 8{\cdot}0^2$ **(1)** $E_k = 2400$ J **(1)**	**3**	
	(b)	(i)	$E_p = mgh$ **(1)** $2400 = 75 \times 9{\cdot}8 \times h$ **(1)** $h = 3{\cdot}3$ m **(1)**	**3**	Or consistent with (a) Accept 1-4 sig fig: 3 m 3·27 m 3·265 m
		(ii)	Energy lost (as heat and sound) due to friction/air resistance	**1**	
	(c)	(i)	Curved path	**1**	Do not accept an indication of competitor and bike rising.
		(ii)	$a = \frac{v-u}{t}$ **(1)** $9{\cdot}8 = \frac{v-0}{0{\cdot}40}$ **(1)** $v = 3{\cdot}9$ m s^{-1} **(1)**	**3**	Accept: $a = \frac{\Delta v}{t}$ OR $v = u + at$ Do not accept a response starting with $a = \frac{v}{t}$ OR $v = at$ Accept 1-4 sig figs: 4 m s^{-1} 3·92 m s^{-1} 3·920 m s^{-1}

MARKS DO NOT WRITE IN THIS MARGIN

4. Within our solar system distances are often measured in astronomical units (AU).

$1\ \text{AU} = 1{\cdot}50 \times 10^{11}\ \text{m}$.

Mars orbits the Sun at an average distance of $1{\cdot}52\ \text{AU}$.

(a) (i) Determine the average distance, in metres, at which Mars orbits the Sun. **1**

Space for working and answer

(ii) Calculate the average time for light from the Sun to reach Mars. **3**

Space for working and answer

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4. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(b) In the future it is hoped that humans will be able to travel to Mars. One challenge of space travel to Mars is maintaining sufficient energy to operate life support systems.

(i) Suggest one solution to this challenge. **1**

(ii) State another challenge of space travel to Mars. **1**

[Turn over

Question			Expected response	Max mark	Additional guidance
4.	(a)	(i)	$d = (1\cdot50\times10^{11}\times1\cdot52)$ $= 2\cdot28\times10^{11}$ (m)	**1**	Unit not required but if stated must be correct. Accept 2-5 sig figs: $2\cdot3\times10^{11}$ $2\cdot280\times10^{11}$ $2\cdot2800\times10^{11}$
		(ii)	$d = vt$ (1) $2\cdot28\times10^{11} = 3\cdot0\times10^{8}\times t$ (1) $t = 760$ s (1)	**3**	Or consistent with (a)(i) Accept 1-4 sig figs: 800 s 760·0 s
	(b)	(i)	Solar cells	**1**	Accept: solar panels Radioisotope Thermoelectric Generator (RTG) nuclear reactors or other suitable answer Solar energy/power alone is insufficient. Nuclear energy/power/reactions alone is insufficient. (Rechargeable) batteries/cells alone is insufficient.
		(ii)	Manoeuvring in zero friction environment **OR** Fuel load on take-off **OR** Potential exposure to radiation **OR** Pressure differential **OR** Re-entry through an atmosphere	**1**	Accept any other suitable answer. Do not accept: 'it takes a long time' alone 'cost'

MARKS DO NOT WRITE IN THIS MARGIN

5. A group of students are watching a video clip of astronauts on board the International Space Station (ISS) as it orbits the Earth.

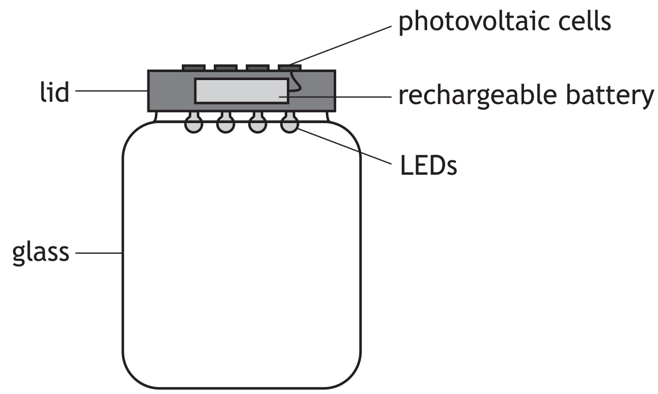
One student states, 'I would love to be weightless and float like the astronauts do on the ISS.'

Using your knowledge of physics, comment on the statement made by the student. **3**

MARKS | DO NOT WRITE IN THIS MARGIN

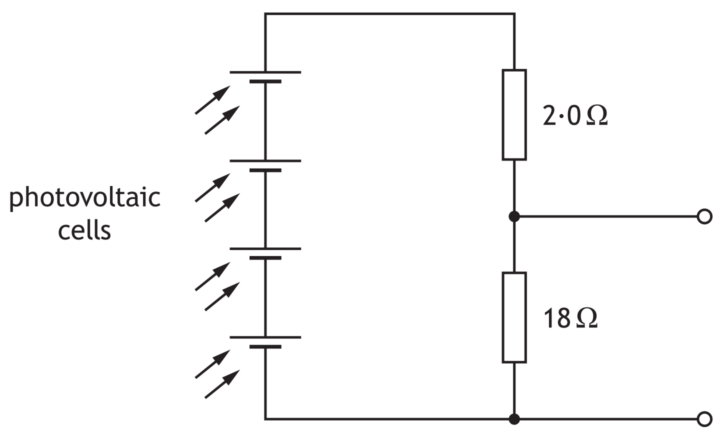
6. A solar jar is designed to collect energy from the Sun during the day and release this energy as light at night.

When the solar jar is placed in sunlight, photovoltaic cells on the lid are used to charge a rechargeable battery.



At night, the rechargeable battery is used to power four identical LEDs.

(a) Part of the circuit in the solar jar is shown.



In direct sunlight the photovoltaic cells produce a combined voltage of 4·0 V.

Calculate the voltage across the 18 Ω resistor. **3**

Space for working and answer

[Turn over

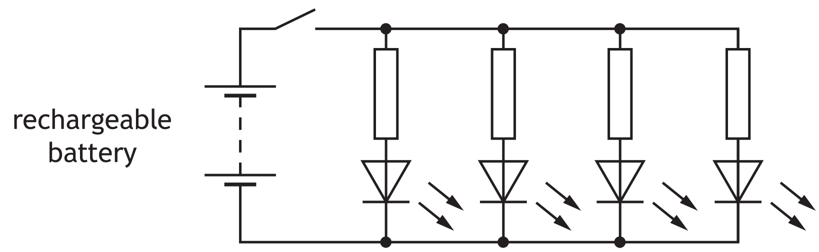
* X 8 5 7 7 5 0 1 1 9 *

Back to Table

6. (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(b) Another part of the circuit containing the LEDs is shown.



The switch is now closed and the LEDs light.

(i) State the purpose of the resistor connected in series with each LED. **1**

(ii) After a few hours the rechargeable battery produces a voltage of 3·4 V.

At this point in time the voltage across each LED is 1·6 V and the current in each LED is 25 mA.

Determine the value of the resistor in series with each LED. **4**

Space for working and answer

* X 8 5 7 7 5 0 1 2 0 *

Back to Table

6. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(c) When the battery is completely discharged it then takes 6·0 hours of direct sunlight to fully charge the battery. During this time, there is a constant current of 0·135 A to the battery.

Calculate the total charge supplied to the battery during this time. **3**

Space for working and answer

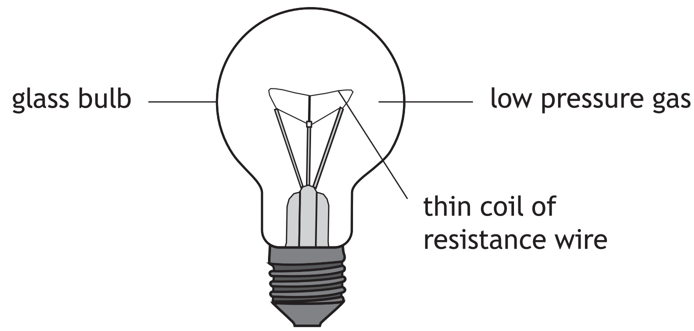
[Turn over

Question			Expected response	Max mark	Additional guidance
6.	(a)		$V_2 = \frac{R_2}{R_1 + R_2} \times V_s$ **(1)** $V_2 = \frac{18}{18 + 2\cdot0} \times 4\cdot0$ **(1)** $V_2 = 3\cdot6$ V **(1)**	3	**Method 2:** $V = IR$ $4\cdot0 = I \times (18 + 2\cdot0)$ $(I = 0\cdot2$ A) $V = IR$ $= 0\cdot2 \times 18$ $= 3\cdot6$ V (1) mark for Ohm's Law (even if only seen once) (1) mark for all substitutions (1) mark for final answer including unit **Method 3:** $\frac{V_1}{V_2} = \frac{R_1}{R_2}$ (1) $\frac{V_1}{4\cdot0} = \frac{18}{20}$ (1) $V_1 = 3\cdot6$ V (1) Accept 1-4 sig figs: 3·60 V 3·600 V Only accept 4 V if there is clear evidence of working and the final value being rounded to 1 sig fig.
	(b)	(i)	To reduce/limit the current (in the LED)	1	Accept: To reduce the voltage **across** the LED OR To protect/prevent damage to the LED

Question			Expected response	Max mark	Additional guidance
6.	(b)	(ii)	$V = 3{\cdot}4 - 1{\cdot}6$ **(1)** (= 1·8 V) $V = IR$ **(1)** $1{\cdot}8 = 25 \times 10^{-3} \times R$ **(1)** $R = 72\ \Omega$ **(1)**	**4**	Calculation of voltage across resistor may be implied by correct substitution. If no attempt to calculate the voltage across resistor, or incorrect substitution to calculate the voltage across resistor, then MAX (1) for relationship. If clear arithmetic error in calculation of voltage across resistor then MAX (3). Accept 1-4 sig figs: 70 Ω 72·0 Ω 72·00 Ω
	(c)		$Q = It$ **(1)** $= 0{\cdot}135 \times 6{\cdot}0 \times 60 \times 60$ **(1)** $= 2900$ C **(1)**	**3**	Accept 1-4 sig figs: 3000 C 2920 C 2916 C

MARKS | DO NOT WRITE IN THIS MARGIN

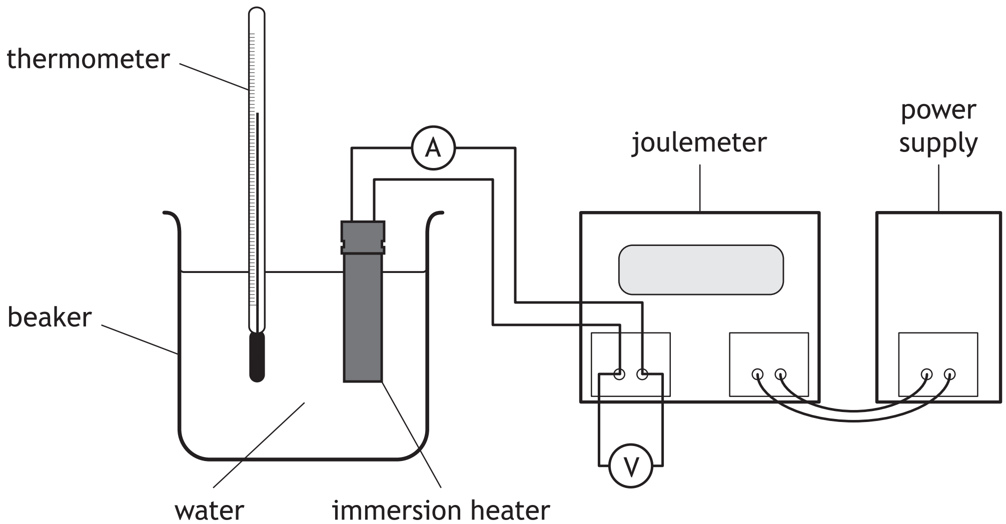
7. A filament lamp consists of a thin coil of resistance wire surrounded by a low pressure gas, enclosed in a glass bulb.



Using your knowledge of physics, comment on the suitability of this design as a light source. **3**

MARKS DO NOT WRITE IN THIS MARGIN

8. A student carries out an experiment, using the apparatus shown, to determine a value for the specific heat capacity of water.



The student switches on the power supply and the immersion heater heats the water.

The joulemeter measures the energy supplied to the immersion heater.

The student records the following measurements.

energy supplied to immersion heater = 21 600 J

mass of water = 0·50 kg

initial temperature of the water = 16 °C

final temperature of the water = 24 °C

reading on voltmeter = 12 V

reading on ammeter = 4·0 A

(a) (i) Determine the value of the specific heat capacity of water obtained from these measurements. **3**

Space for working and answer

* X 8 5 7 7 5 0 1 2 4 *

MARKS DO NOT WRITE IN THIS MARGIN

8. (a) (continued)

(ii) Explain why the value determined from the experiment is different from the value quoted in the data sheet. 1

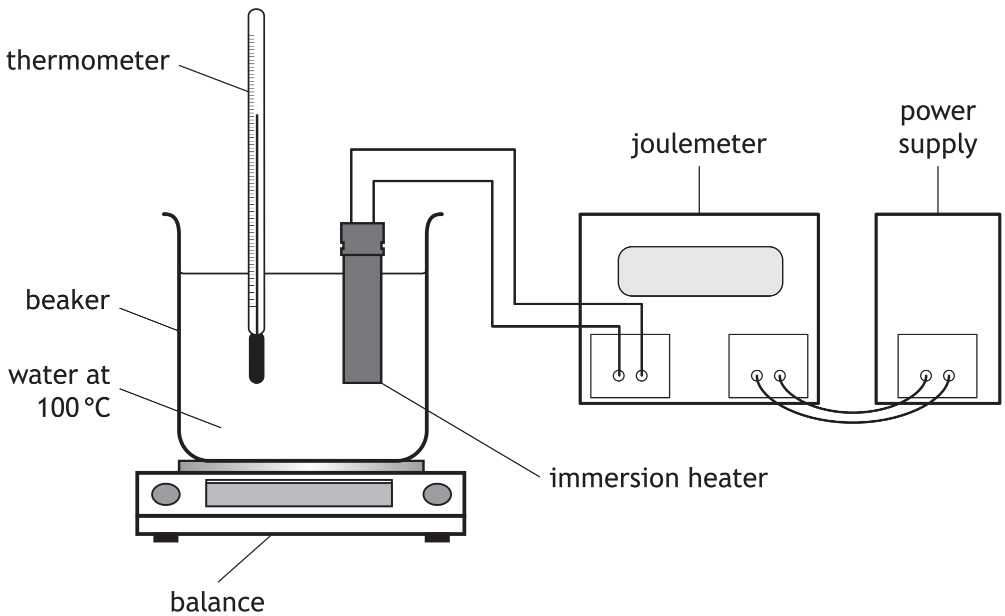
(b) Calculate the time for which the immersion heater is switched on in this experiment. 4

Space for working and answer

[Turn over

8. (continued) MARKS DO NOT WRITE IN THIS MARGIN

(c) The student then carries out a second experiment, using the apparatus shown, to determine a value for the specific latent heat of vaporisation of water.



Describe how this apparatus would be used to determine a value for the specific latent heat of vaporisation of water. **3**

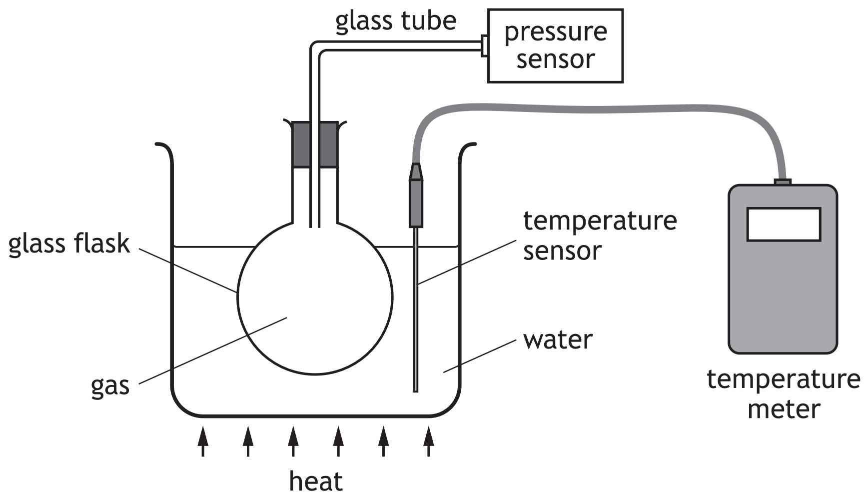
Your description must include:

- measurements made
- any necessary calculations

Question			Expected response	Max mark	Additional guidance
8.	(a)	(i)	$E_h = cm\Delta T$ **(1)** $21\ 600 = c \times 0{\cdot}50 \times (24 - 16)$ **(1)** $c = 5\ 400\ \text{J kg}^{-1}\ {}^\circ\text{C}^{-1}$ **(1)**	**3**	Calculation of temperature change may be implied by correct substitution. If no attempt to calculate the temperature change, or incorrect substitution to calculate the temperature change, then MAX (1) for relationship. If clear arithmetic error in calculation of temperature change then MAX (2). Accept 1-4 sig figs: $5\ 000\ \text{J kg}^{-1}\ {}^\circ\text{C}^{-1}$
		(ii)	Heat (energy) is lost to the surroundings/to air. OR some of the heat (energy) is used to heat up the heater/beaker.	**1**	Accept: not all the heat (energy) is transferred into the water. Do not accept: 'heat loss' alone – it must be clear where it is going.
	(b)		$P = IV$ **(1)** $= 4{\cdot}0 \times 12$ $= 48\ (\text{W})$ $P = \dfrac{E}{t}$ (1) $48 = \dfrac{21600}{t}$ (1) $t = 450\ \text{s}$ (1)	**4**	(1) each relationship (1) for all substitutions (1) final answer and unit Alternative method: $E = ItV$ (1)+(1) $21\ 600 = 4{\cdot}0 \times t \times 12$ (1) $t = 450\ \text{s}$ (1) Accept 1-4 sig figs: 500 s 450·0 s
	(c)		(Measure the) mass of water evaporated. **(1)** (Measure the) energy supplied. **(1)** $E_h = ml$ **(1)**	**3**	Independent marks Accept: 'loss in mass' 'difference in mass' Do not accept: 'reading on joulemeter' alone Do not accept: answers that involve using additional apparatus to measure the energy (eg stopclocks, ammeters and voltmeters).

MARKS | DO NOT WRITE IN THIS MARGIN

9. A student sets up an experiment to investigate the relationship between the pressure and temperature of a fixed mass of gas as shown.



(a) The student heats the water and records the following readings of pressure and temperature.

Pressure (kPa)	101	107	116	122
Temperature (K)	293	313	333	353

(i) Using **all** the data, establish the relationship between the pressure and the temperature of the gas. **3**

Space for working and answer

Back to Table

9. (a) (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(ii) Using the kinetic model, explain why the pressure of the gas increases as its temperature increases. **3**

(iii) Predict the pressure reading which would be obtained if the student was to cool the gas to 253 K. **1**

(b) State one way in which the set-up of the experiment could be improved to give more reliable results.

Justify your answer. **2**

[Turn over

* X 8 5 7 7 5 0 1 2 9 *

Back to Table

Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	All four substitutions for $\frac{p}{T}$ OR $\frac{T}{p}$ **(1)** All values calculated correctly **(1)** For $\frac{p}{T}$: $\frac{101\times10^3}{293} = 345$ $\frac{107\times10^3}{313} = 342$ $\frac{116\times10^3}{333} = 348$ $\frac{122\times10^3}{353} = 346$ For $\frac{T}{p}$: $\frac{293}{101\times10^3} = 0{\cdot}00290$ $\frac{313}{107\times10^3} = 0{\cdot}00293$ $\frac{333}{116\times10^3} = 0{\cdot}00287$ $\frac{353}{122\times10^3} = 0{\cdot}00289$ Statement of: $\frac{p}{T} = constant$ OR $\frac{T}{p} = constant$ OR $\frac{p_1}{T_1} = \frac{p_2}{T_2}$ OR p is (directly) proportional to T (in kelvin) **(1)**	3	If only 1 or 0 sets of data used (0) for entire question Substitutions may be implied by all four calculated values. For the second mark, values must be calculated correctly for all substitutions shown by the candidate (minimum of using at least two sets of data). Accept 2-5 sig figs in all calculated values. Conversion from kPa to Pa not required. Mark for $\frac{p}{T} = \text{constant}$ can only be accessed if the candidate has completed calculations using a minimum of two sets of data, however the relationship must be supported by all the candidate's calculated values. Do not accept $\frac{pV}{T} = constant$ **Graphical method:** Must be on graph paper for any marks to be awarded suitable scales, labels and units (1) all points plotted accurately to ±half a division and line of best fit (1) relationship stated (1)

Question			Expected response	Max mark	Additional guidance
					Alternative method: If candidate uses $\frac{p_1}{T_1} = \frac{p_2}{T_2}$ to verify values of pressures or temperatures in the table then they must make it clear that the calculated value is approximately the same as the value in the table for any marks to be awarded. Thereafter: All four sets of data linked (minimum of three calculations) (1) All calculations correct (1) Relationship stated and supported (1)
9.	(a)	(ii)	(The increase in temperature) increases the kinetic energy of the gas particles/the particles move faster. **(1)** The particles hit the container/walls more frequently. **(1)** The particles hit the container/walls with greater force. **(1)**	**3**	Independent marks Accept: 'atoms'/'molecules' in place of 'particles' Do not accept: 'particles hit the container/walls more' alone
		(iii)	Any single value between 83 kPa and 89 kPa inclusive	**1**	Unit must be stated Excessive sig figs should be ignored.
	(b)		Have more of the flask under the water, **(1)** so that the gas is at the same temperature/evenly heated **(1)** **OR** Reduce the length/diameter/volume of the connecting tube **(1)** so that the gas is at the same temperature/evenly heated **(1)**	**2**	Accept: Place the temperature sensor in the flask (1) So that the temperature of the gas is being measured (1) Accept: 'so that all the gas is being heated' Do not accept: 'repeat measurements' – it is an improvement to the set up that is required

10. A student connects a mobile phone to a speaker wirelessly using a microwave signal.

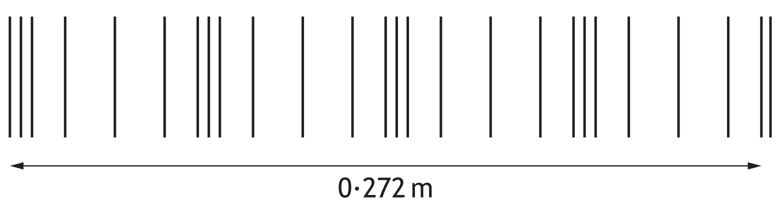
(a) The time taken for the microwave signal to travel from the mobile phone to the speaker is $2\cdot1 \times 10^{-8}$ s.

Calculate the distance between the mobile phone and the speaker. **3**

Space for working and answer

(b) Sound is a longitudinal wave.

The sound produced by the speaker is represented by the following diagram.



(i) State what is meant by the term *longitudinal wave*. **1**

MARKS DO NOT WRITE IN THIS MARGIN

10. (b) (continued)

(ii) Determine the wavelength of the sound wave. **1**

Space for working and answer

(iii) Calculate the frequency of the sound wave in air. **3**

Space for working and answer

[Turn over

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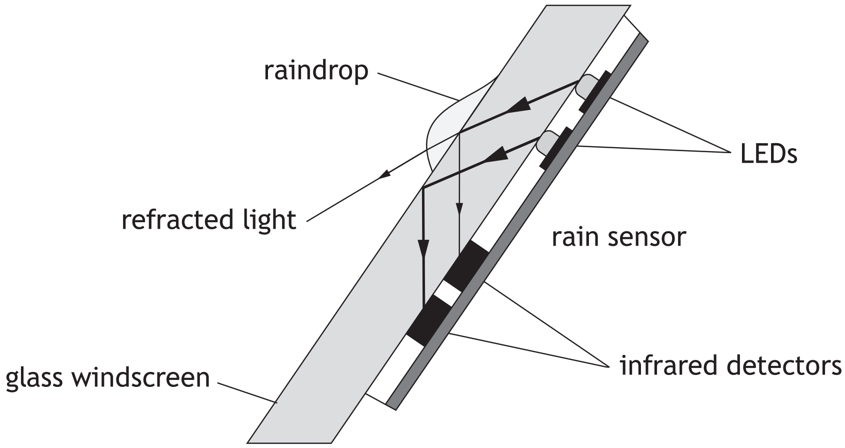
Question			Expected response	Max mark	Additional guidance
10.	(a)		$d = vt$ **(1)** $d = 3 \cdot 0 \times 10^8 \times 2 \cdot 1 \times 10^{-8}$ **(1)** $d = 6 \cdot 3$ m **(1)**	**3**	Accept 1-4 sig figs: 6 m 6·30 m 6·300 m
	(b)	(i)	(Particle) vibrations/oscillations are in the same direction as the energy transfer. **OR** (Particle) vibrations/oscillations are in the same direction as the wave is travelling.	**1**	Accept: 'particles move forward and backward/to and fro' to indicate a vibration. Do not accept: 'particles move in the same direction...'.
		(ii)	$(\lambda = \frac{0{\cdot}272}{4})$ $\lambda = 0 \cdot 068$ m **(1)**	**1**	Unit must be stated.
		(iii)	$v = f\lambda$ **(1)** $340 = f \times 0 \cdot 068$ **(1)** $f = 5000$ Hz **(1)**	**3**	Or consistent with (b)(ii) Accept 1-4 sig figs

MARKS | DO NOT WRITE IN THIS MARGIN

11. A rain sensor is attached to the glass windscreen of a vehicle to automatically control the windscreen wipers.



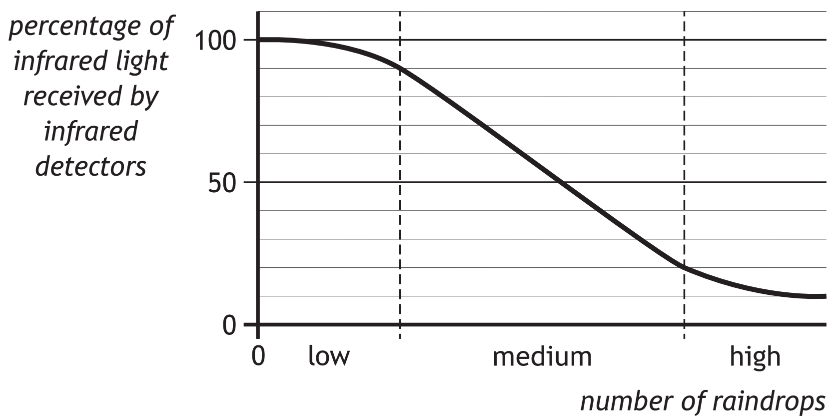
Infrared light is emitted from LEDs and is received by infrared detectors.

(a) State a suitable detector of infrared radiation for this rain sensor. **1**

11. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(b) The graph shows how the number of raindrops affects the percentage of infrared light received by the infrared detectors.



The percentage of infrared light received by the infrared detectors from the LEDs controls the frequency with which the windscreen wipers move back and forth.

The table shows how the number of times the windscreen wipers move back and forth per minute relates to the number of raindrops.

Number of raindrops	*Number of times the windscreen wipers move back and forth per minute*
low	18
medium	54
high	78

At one point in time the infrared detectors receive 70% of the infrared light emitted from the LEDs.

Show that the frequency of the windscreen wipers at this time is 0·90 Hz. **3**

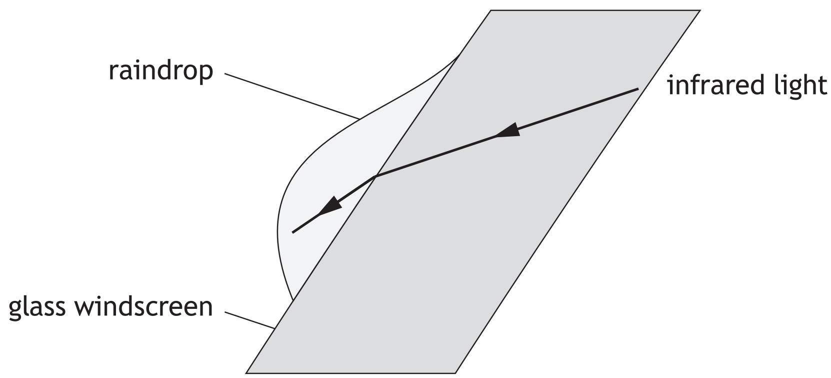
Space for working and answer

[Turn over

11. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(c) Some of the infrared light is refracted when travelling from the glass windscreen into a raindrop.



(i) On the diagram, draw and label:

(A) a normal; **1**

(B) an angle of incidence i and an angle of refraction r. **1**

(An additional diagram, if required, can be found on *page 44*.)

(ii) State whether the wavelength of the infrared light in the raindrop is less than, equal to or greater than the wavelength of the infrared light in the glass.

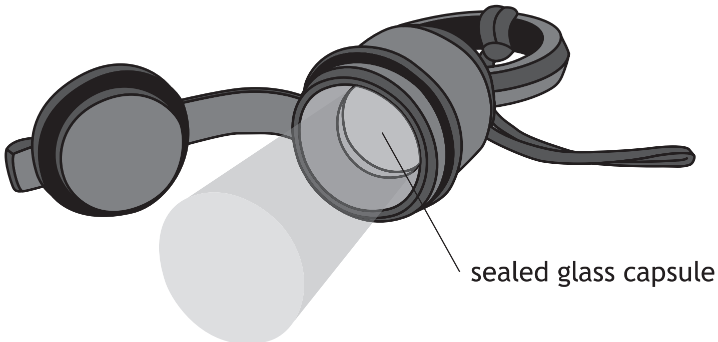
You **must** justify your answer. **2**

Question			Expected response	Max mark	Additional guidance
11.	(a)		Any one of: • photodiode • phototransistor • thermistor • LDR • thermocouple • thermopile • CCD.	**1**	Do not accept: • skin • (infrared) camera • (thermal imaging) camera • photographic film • thermogram • (black bulb) thermometer • thermochromic film. Apply +/- rule for surplus answers.
	(b)		$N = 54$ **(1)** $f = \dfrac{N}{t}$ **(1)** $f = \dfrac{54}{60}$ **(1)** $f = 0 \cdot 90$ Hz	**3**	**'Show' question** Must state the correct relationship or MAX (1) for identifying $N = 54$. Final answer of 0·90 Hz or 0·9 Hz, including unit, must be shown, otherwise MAX (2). **Alternative method:** Marks can only be awarded for this method if substitution for calculation of the period is shown. $T = \dfrac{60}{54} (= 1 \cdot 11)$ **(1)** $f = \dfrac{1}{T}$ **(1)** $f = \dfrac{1}{1 \cdot 11}$ **(1)** $f = 0 \cdot 90$ Hz For alternative methods calculating N or t, there must be a final statement to show the calculated value of N or t is the same as the value stated in the question.
	(c)	(i) (A)	Normal drawn and labelled	**1**	Must be 'passably' perpendicular and straight and must appear in both materials. Does not need to be dashed Accept: 'N', 'n' or 'A' as label

Question			Expected response	Max mark	Additional guidance
11.	(c)	(i) (B)	Both angles indicated and labelled	**1**	Accept: i and r I and R θ_i and θ_r If normal has been incorrectly drawn, then this mark is still accessible, provided angles are indicated to the normal within each material and labelled.
		(ii)	(Wavelength in water is) greater (than in glass). **(1)** Speed of light (in water) is greater (than in glass). **(1)**	**2**	First mark can only be awarded if justification is attempted Effect correct + justification correct (2) Effect correct + justification incomplete (1) Effect correct + justification incorrect (wrong physics) (0) Effect correct + no justification attempted (0) Incorrect or no effect stated regardless of justification (0) Accept: ‘refractive index in water is less than glass’ ‘water is less optically dense than glass’ for justification The effect can be justified by appropriate calculations.

MARKS | DO NOT WRITE IN THIS MARGIN

12. A tritium torch includes a sealed glass capsule containing radioactive tritium gas.



Beta particles emitted by the tritium gas are absorbed by a coating on the inside of the glass capsule.

The coating then emits visible light.

(a) State what is meant by a *beta particle*. **1**

(b) The half-life of tritium gas is 12·3 years.

The manufacturer states that the torch will work effectively for 15 years.

Explain why the torch will be less effective after this time. **2**

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Back to Table

12. (continued) **MARKS** DO NOT WRITE IN THIS MARGIN

(c) During the manufacturing process a glass capsule cracks and a worker receives an absorbed dose of 0·40 mGy throughout their body from the tritium gas.

The mass of the worker is 85 kg.

(i) Calculate the energy of the radiation absorbed by the worker. **3**

Space for working and answer

(ii) Calculate the equivalent dose received by the worker. **3**

Space for working and answer

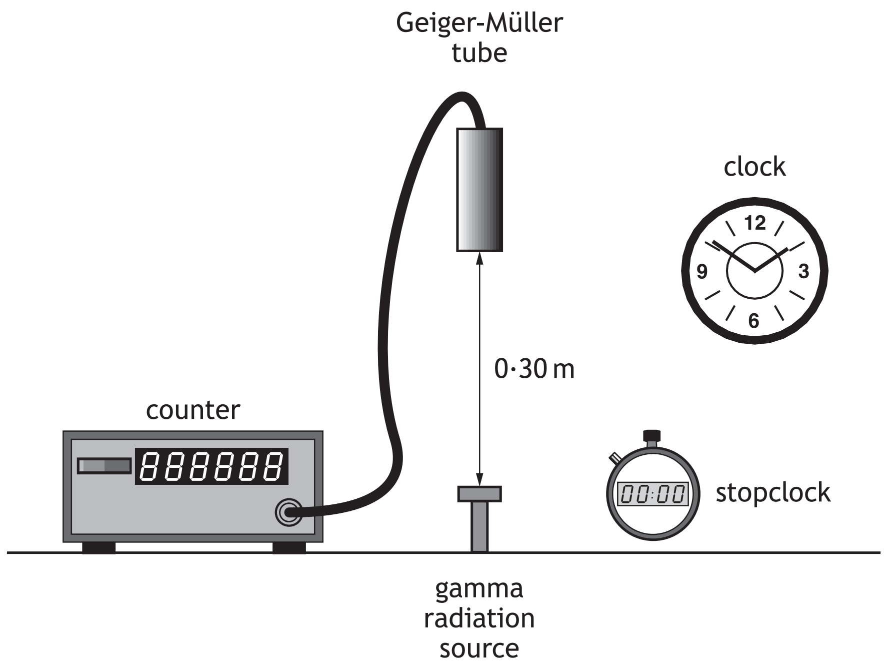
[Turn over

Back to Table

Question			Expected response	Max mark	Additional guidance
12.	(a)		Fast/high-energy electron	**1**	Accept: ‘an electron from the nucleus’ Do not accept: ‘electron’ alone
	(b)		Activity of tritium source is less/ fewer beta particles emitted per second. **(1)** Less light produced **(1)**	**2**	Independent marks Accept: ‘activity will have halved’. Do not accept: ‘radioactivity’ in place of activity.
	(c)	(i)	$D = \frac{E}{m}$ **(1)** $0\cdot 40 \times 10^{-3} = \frac{E}{85}$ **(1)** $E = 0\cdot 034\ \text{J}$ **(1)**	**3**	Accept 1-4 sig figs: 0·03 J 0·0340 J 0·03400 J
		(ii)	$H = Dw_r$ **(1)** $= 0\cdot 40 \times 10^{-3} \times\ 1$ **(1)** $= 4\cdot 0 \times 10^{-4}\ \text{Sv}$ **(1)**	**3**	Accept 1–4 sig figs: 4×10^{-4} Sv $4{\cdot}00 \times 10^{-4}$ Sv $4{\cdot}000 \times 10^{-4}$ Sv

MARKS | DO NOT WRITE IN THIS MARGIN

13. A technician carries out an experiment, using the apparatus shown, to determine the half-life of a gamma radiation source.



(a) Before carrying out the experiment the technician measures the background count rate.

(i) Explain why this measurement is made. **1**

(ii) State a source of background radiation. **1**

[Turn over

13. (continued)

(b) The technician's results are shown in the table.

Time (minutes)	*Corrected count rate* (counts per minute)
0	680
20	428
40	270
60	170
80	107
100	68

(i) Using the graph paper below, draw a graph of these results. **3**

(Additional graph paper, if required, can be found on *page 45*.)

13. (b) (continued) **MARKS** DO NOT WRITE IN THIS MARGIN

(ii) Use your graph to determine the half-life of the gamma radiation source. **1**

(c) The technician repeats the experiment with an alpha radiation source.

(i) Suggest a change the technician must make to the experimental set-up to determine the half-life of the alpha radiation source.

Justify your answer. **2**

(ii) During the first 15 s of the experiment the alpha radiation source has an average activity of 520 Bq.

Calculate the number of nuclear disintegrations that occur in the source in the first 15 s of the experiment. **3**

Space for working and answer

[END OF QUESTION PAPER]

Question			Expected response	Max mark	Additional guidance
13.	(a)	(i)	The counter reading will include the source and background count. **OR** Background will need to be subtracted. **OR** To measure/determine the count rate due to the source.	**1**	
		(ii)	Any suitable source	**1**	Apply +/- rule for surplus answers. Do not accept: Cosmic Microwave Background Radiation.
	(b)	(i)	Suitable scales, labels and units **(1)** All points plotted accurately to ±half a division **(1)** Best fit <u>curve</u> **(1)**	**3**	A non-linear scale on either axis prevents access to any marks. (0) No marks for a bar graph (0) Axes can be transposed
		(ii)	30 minutes	**1**	Or consistent with best fit curve from (b)(i) Or consistent with best fit line or dot-to-dot line ±Half a division tolerance Unit must be stated.
	(c)	(i)	Reduce the distance (between the detector and the source). **(1)** Alpha is absorbed by a few cm of air/range in air is a few cm. **OR** Alpha has a shorter range (than gamma). **(1)**	**2**	Suggestion must be correct, otherwise (0 marks). Accept: 'move the source closer (to the detector)'. Do not accept: 'alpha is weaker/gamma is stronger'.
		(ii)	$A=\frac{N}{t}$ **(1)** $520=\frac{N}{15}$ **(1)** $N=7800$ **(1)**	**3**	No unit required but if wrong unit stated MAX (2). Accept 1–4 sig figs: 8000

[END OF MARKING INSTRUCTIONS]

SECTION 1

Attempt ALL questions

1. Which of the following are **both** vectors?

A weight and acceleration
B kinetic energy and acceleration
C mass and acceleration
D force and speed
E speed and acceleration

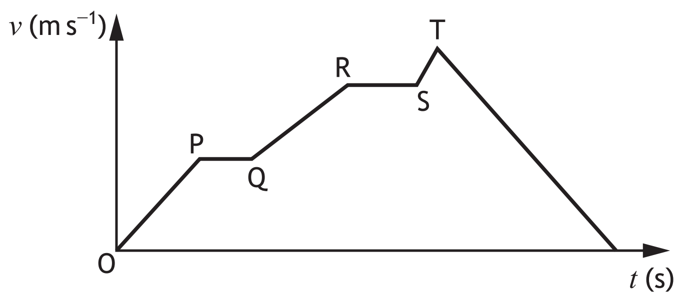
2. A car is travelling at $6{\cdot}0\,m\,s^{-1}$ along a straight level road.

The car then accelerates uniformly at $2{\cdot}0\,m\,s^{-2}$ for $4{\cdot}0\,s$.

The final speed of the car is

A $8{\cdot}0\,m\,s^{-1}$
B $14\,m\,s^{-1}$
C $22\,m\,s^{-1}$
D $26\,m\,s^{-1}$
E $48\,m\,s^{-1}$.

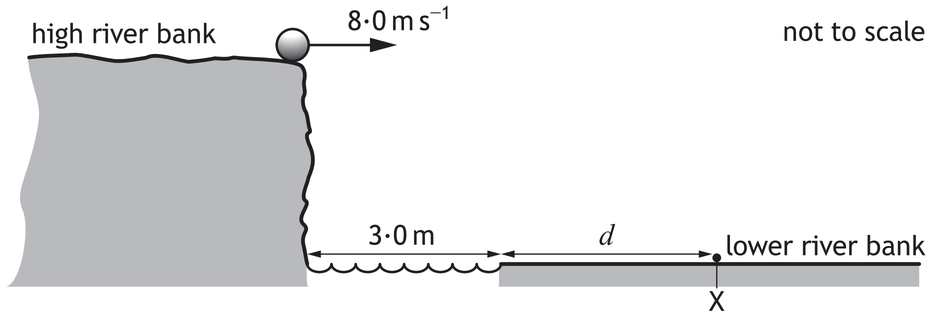
3. The graph shows how the speed v of a car varies with time t.



During which part of the journey does the car have the greatest acceleration?

A OP
B PQ
C QR
D RS
E ST

4. A ball is kicked horizontally off a high river bank as shown.



The ball lands on the lower river bank at X, 2·0 s after the ball is kicked.

The river is 3·0 m wide.

The effect of air resistance on the ball is negligible.

The distance d between the edge of the lower river bank and X is

A 1·0 m

B 4·0 m

C 13 m

D 16 m

E 19 m.

5. The table gives the distance from Earth, the approximate surface temperature and the age of five stars.

Star	Distance from Earth (light-years)	Approximate surface temperature (K)	Age (years)
Sirius A	8·6	9900	$2{\cdot}4 \times 10^{8}$
Polaris	430	6000	$7{\cdot}0 \times 10^{7}$
Betelgeuse	640	3600	$7{\cdot}9 \times 10^{6}$
Rigel	860	11 000	$8{\cdot}0 \times 10^{6}$
VY Canis Majoris	3900	3500	$1{\cdot}0 \times 10^{7}$

A student makes the following statements based on this information.

I As the distance from Earth increases, the age of a star decreases.

II As the age of a star increases, the approximate surface temperature of the star increases.

III There is no apparent relationship between the distance from Earth and the approximate surface temperature of a star.

Which of these statements is/are correct?

A I only

B II only

C III only

D I and III only

E I, II and III

[Turn over

6. A geostationary satellite orbits the Earth.

Which row in the table shows the altitude above the surface of the Earth and orbital period of the geostationary satellite?

	Altitude above the surface of the Earth (km)	Orbital period (hours)
A	36 000	12
B	36 000	24
C	36 000	48
D	18 000	12
E	18 000	24

7. The weight of a robot on Earth is 240 N.

The weight of the robot on Mars is

A 3·7 N
B 65 N
C 91 N
D 240 N
E 890 N.

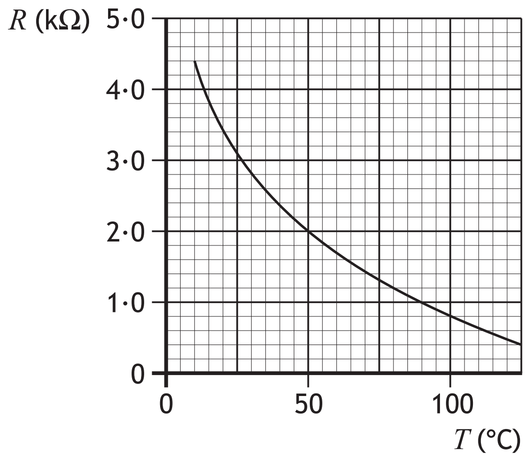
8. A hairdryer is connected to a 230 V supply.

The current in the hairdryer is 2·0 A.

The electrical charge that passes through the hairdryer in 5 minutes is

A 10 C
B 460 C
C 600 C
D 1150 C
E 69 000 C.

9. The graph shows how the resistance R of a thermistor varies with temperature T.



The thermistor is connected in a circuit.

At a temperature of 50 °C the current in the thermistor is 0·004 A.

At this temperature the voltage across the thermistor is

A 0·000 02 V

B 0·002 V

C 0·008 V

D 8 V

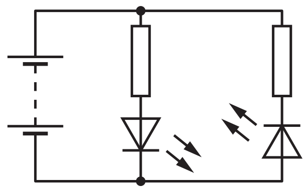
E 500 V.

[Turn over

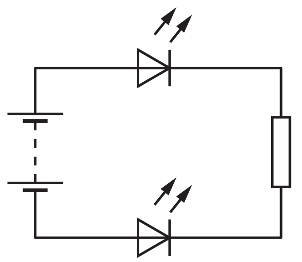
10. A student sets up the circuits shown.

In which circuit will both LEDs be lit?

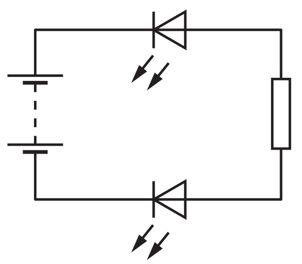
A



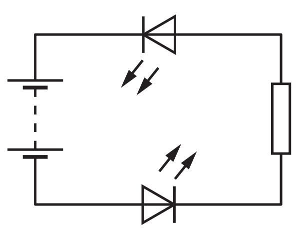
B



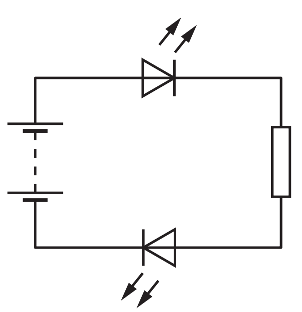
C



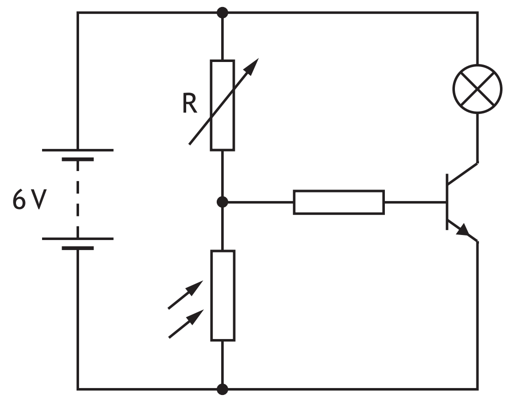
D



E



11. A circuit is set up as shown.



The room temperature is 20 °C.

The lamp is off.

The lamp will light when

A the light level is decreased below a certain value

B the light level is increased above a certain value

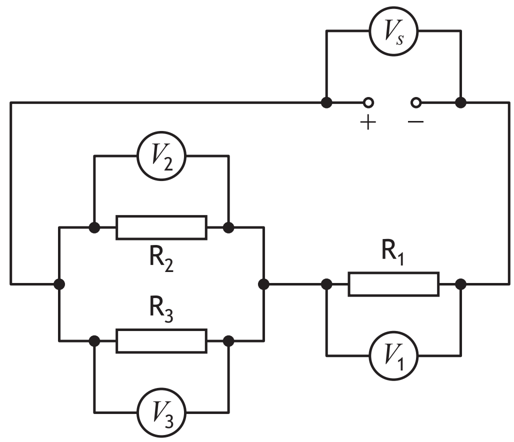
C the resistance of R is increased above a certain value

D the battery voltage is reduced to 5 V

E the temperature is increased above a certain value.

[Turn over

12. A circuit is set up as shown.



A student makes the following statements about the readings on the voltmeters.

I $V_1 = V_2$

II $V_2 = V_3$

III $V_S = V_1 + V_2$

Which of these statements must **always** be true?

A II only

B I and II only

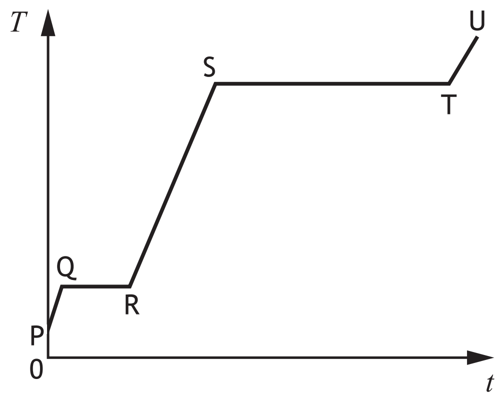
C I and III only

D II and III only

E I, II and III

13. A solid substance is placed in an insulated container and heated.

The graph shows how the temperature T of the substance varies with time t.



To calculate the specific latent heat of fusion of the substance a student would use the time from section

A PQ

B QR

C RS

D ST

E TU.

14. The pressure p due to a liquid at a depth h is given by the relationship

$$p = \rho g h$$

where ρ is the density of the liquid and g is the gravitational field strength.

A liquid has a density of 990 kg m^{-3}.

When the pressure due to the liquid is 1470 Pa, the depth in the liquid is

A 0·069 m

B 0·15 m

C 0·67 m

D 1·5 m

E 6·6 m.

[Turn over

15. A car is parked in the sun for some time. During this time the air pressure inside the tyres increases.

The reason for this increase in pressure is

A the volume occupied by the air particles in the tyres has increased

B the force produced by the air particles in the tyres acts over a smaller area

C the average spacing between the air particles in the tyres has increased

D the increased temperature has made the air particles in the tyres expand

E the air particles in the tyres are moving with greater kinetic energy.

16. The temperature of a sample of gas in a container is 20 °C.

The volume of the gas is $0{\cdot}30\,m^3$.

The container is free to expand in order to maintain a constant pressure.

The temperature of the gas is increased to 50 °C.

The volume now occupied by the gas is

A $0{\cdot}12\,m^3$

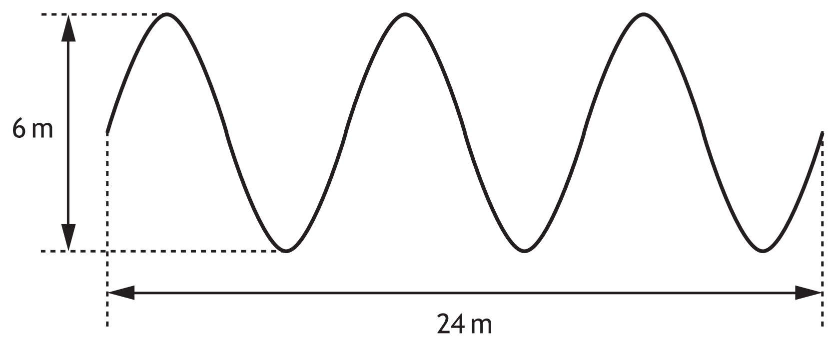
B $0{\cdot}27\,m^3$

C $0{\cdot}30\,m^3$

D $0{\cdot}33\,m^3$

E $0{\cdot}75\,m^3$.

17. The following diagram gives information about a wave.



Which row in the table shows the amplitude and wavelength of the wave?

	Amplitude (m)	Wavelength (m)
A	3	4
B	3	8
C	6	4
D	6	8
E	8	3

18. A student is studying waves with a period of 80·0 ms and a wavelength of 4·00 m.

The frequency of these waves is

A 0·0125 Hz

B 0·320 Hz

C 12·5 Hz

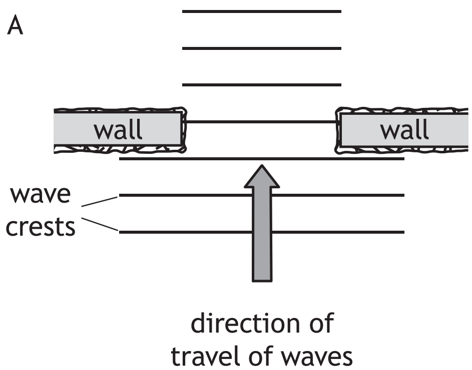
D 80·0 Hz

E 320 Hz.

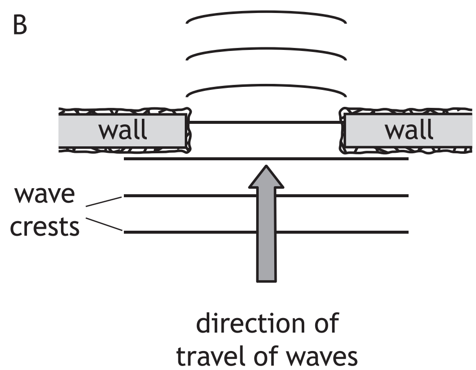
[Turn over

19. Which of the following diagrams shows the diffraction of water waves as they pass between two walls?

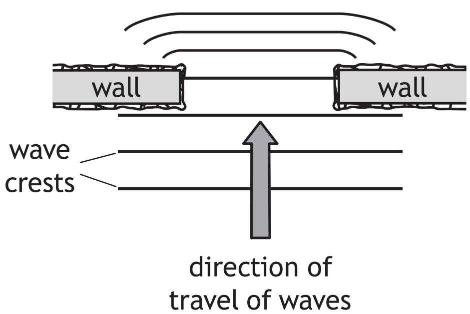
A



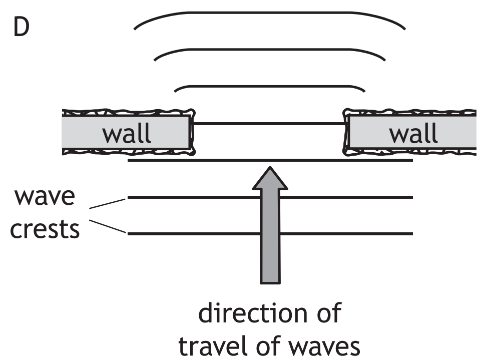
B



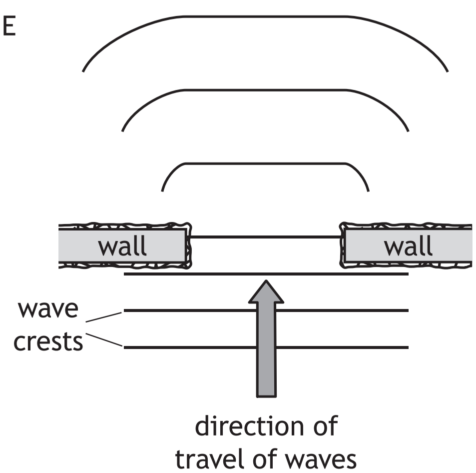
C



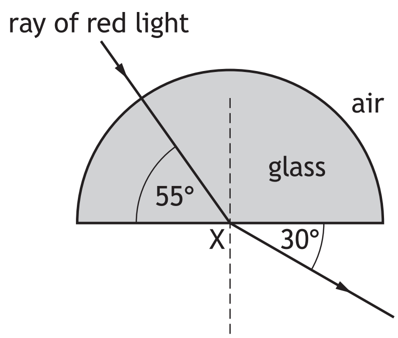
D



E



20. A ray of red light passes through a glass block as shown.

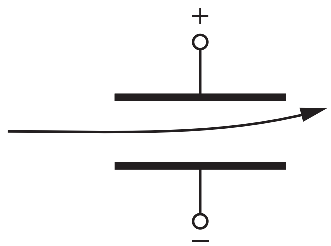
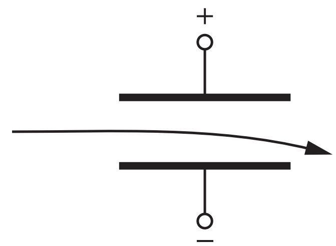
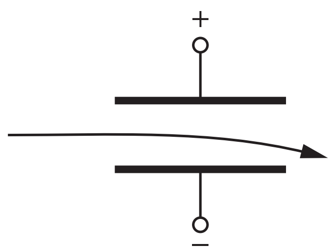
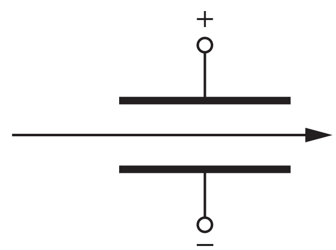
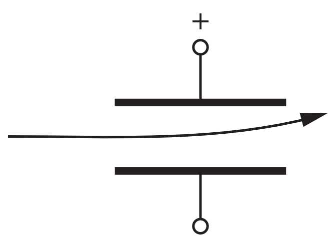
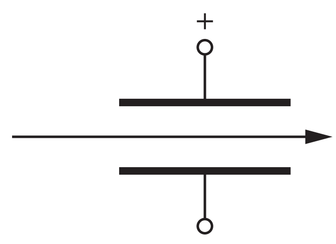
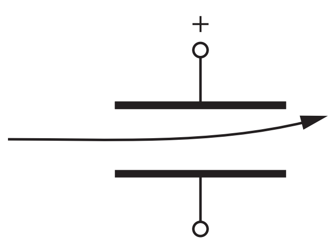
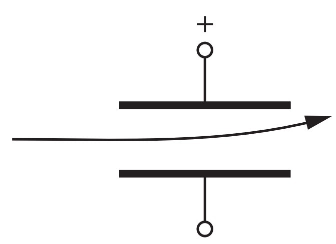
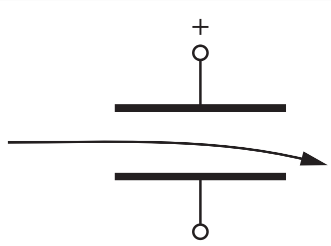
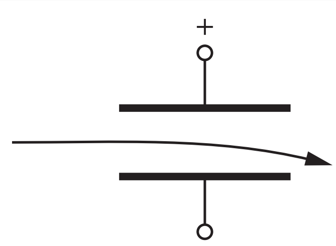


Which row in the table shows the angle of incidence and the corresponding angle of refraction at point X?

	Angle of incidence	Angle of refraction
A	35°	60°
B	30°	55°
C	35°	30°
D	55°	30°
E	60°	35°

[Turn over

21. Which row in the table shows the paths taken by alpha particles and gamma radiation as they pass through a uniform electric field between two metal plates?

	Path taken by alpha particles	Path taken by gamma radiation
A		
B		
C		
D		
E		

22. For a particular radioactive source, 1800 atoms decay in a time of 3 minutes.

The activity of the source is

A 10 Bq

B 600 Bq

C 1800 Bq

D 5400 Bq

E 324 000 Bq.

23. The crew on an aircraft during a transatlantic flight are exposed to cosmic radiation at an equivalent dose rate of $5 \cdot 0\ \mu Sv\ h^{-1}$.

The crew complete 6 transatlantic flights each month. The average duration of a flight is 8 hours.

The equivalent dose received by the crew due to cosmic radiation during transatlantic flights in **one year** is

A 30 μSv

B 40 μSv

C 60 μSv

D 240 μSv

E 2880 μSv.

24. A radioactive tracer is injected into a patient to enable doctors to check the function of a patient's kidneys.

Radiation from the tracer is monitored outside the patient's body by a detector.

Which row in the table shows the most suitable type of radiation emitted and the half-life for the tracer?

	Type of radiation emitted	**Half-life of tracer**
A	alpha	6 hours
B	beta	6 hours
C	beta	6 years
D	gamma	6 hours
E	gamma	6 years

[Turn over for next question

25. The activity of a radioactive source is 56 MBq.

The activity of the source 40 hours later is 3·5 MBq.

The half-life of this source is

A 8 hours

B 10 hours

C 16 hours

D 20 hours

E 28 hours.

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET]

Marking Instructions for each question

Section 1

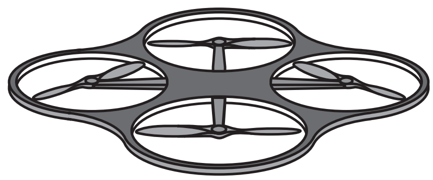
Question	Answer	Mark
1.	A	1
2.	B	1
3.	E	1
4.	C	1
5.	C	1
6.	B	1
7.	C	1
8.	C	1
9.	D	1
10.	E	1
11.	A	1
12.	D	1
13.	B	1
14.	B	1
15.	E	1
16.	D	1
17.	B	1
18.	C	1
19.	D	1
20.	A	1
21.	B	1
22.	A	1
23.	E	1
24.	D	1
25.	B	1

DO NOT WRITE IN THIS MARGIN

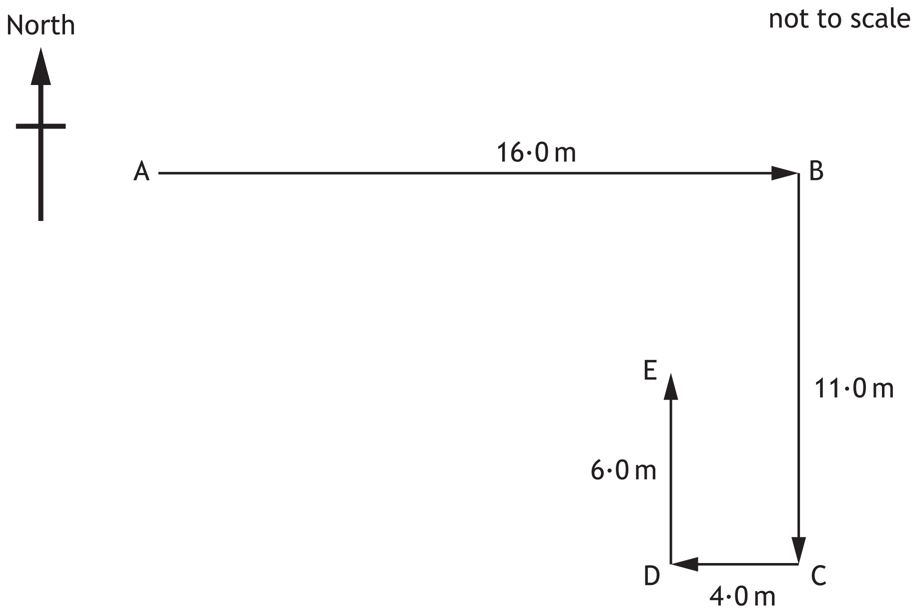
SECTION 2 — 110 marks

Attempt ALL questions

1. A quadcopter is a drone with four rotating blades.



(a) In a race, the quadcopter is flown along a route from point A to point E.



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Back to Table

MARKS DO NOT WRITE IN THIS MARGIN

1. (a) (continued)

(i) By scale drawing or otherwise, determine the magnitude of the resultant displacement of the quadcopter from point A to point E. **2**

Space for working and answer

(ii) By scale drawing or otherwise, determine the direction of the resultant displacement of the quadcopter from point A to point E. **2**

Space for working and answer

[Turn over

Back to Table

MARKS | DO NOT WRITE IN THIS MARGIN

1. (continued)

(b) The quadcopter takes 32·5 s to complete the race.

Determine the average velocity of the quadcopter over the whole race. **3**

Space for working and answer

(c) A second quadcopter completes the race at an average speed of 1·25 m s^{-1}.

The distance travelled by this quadcopter during the race is 37·0 m.

Determine the **difference** in the times taken by the quadcopters to complete the race. **3**

Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

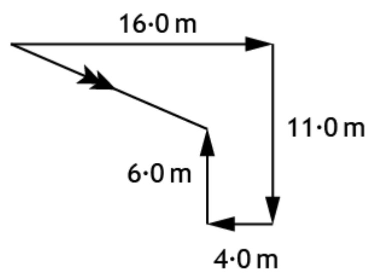
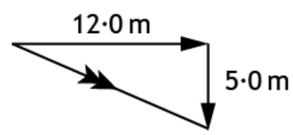
1. (continued)

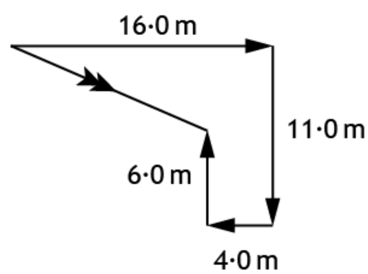
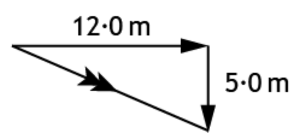
(d) After passing point E, the quadcopter hovers at a constant height.

Describe how the overall lift force provided by the four rotating blades compares to the weight of the quadcopter. **1**

[Turn over

Section 2

Question			Expected response	Max mark	Additional guidance
1	(a)	(i)	Using Pythagoras: $\text{Resultant}^2 = 12{\cdot}0^2 + 5{\cdot}0^2$ **(1)** $\text{Resultant} = 13\text{m}$ **(1)** Using scale diagram:  **or**  Vectors to scale **(1)** $\text{Resultant} = 13\text{m}$ **(1)** (allow ± 0·5 m tolerance)	**2**	Ignore any direction stated in the final answer in this part. If clear arithmetic error shown in 16 – 4 = 12 or 11 – 6 = 5 then MAX (1) mark for substitution consistent with arithmetic error. No requirement for arrows to be shown on diagram to calculate the magnitude of displacement. Regardless of method, if a candidate shows a vector diagram (or a representation of a vector diagram ie a triangle with no arrows) **and** the vectors have been added incorrectly, eg head-to-head then MAX (1).

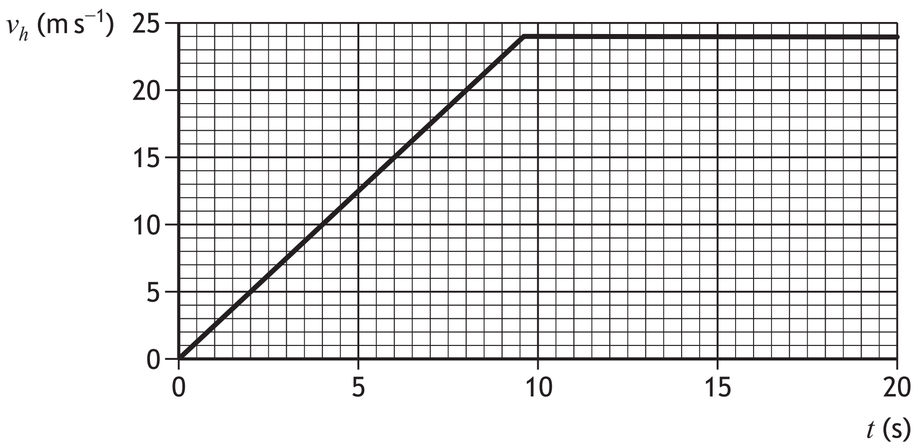
Question			Expected response	Max mark	Additional guidance
		(ii)	Using trigonometry: $\tan\theta = \frac{5 \cdot 0}{12 \cdot 0}$ **(1)** $(\theta = 23°)$ direction=113 **(1)** Using scale diagram:  **or**  Vectors to scale **(1)** Direction=113 **(1)** (allow ±2° tolerance)	**2**	Or use of resultant value (and appropriate trigonometry) consistent with (a)(i). Accept: 23° South of East 67° East of South Ignore the degree symbol if the direction is stated as a bearing. Can also do using other trig functions, eg $\sin\theta = \frac{5 \cdot 0}{13}$ or $\cos\theta = \frac{12 \cdot 0}{13}$ Regardless of method, if a candidate shows a vector diagram (or a representation of a vector diagram ie a triangle with no arrows) **and** the vectors have been added incorrectly, eg head-to-head then MAX (1). Accept: 20° S of E 110 22·6° S of E 112·6 22·62° S of E 112·62
	(b)		$s = \bar{v}t$ **(1)** $13 = \bar{v} \times 32 \cdot 5$ **(1)** $\bar{v} = 0 \cdot 40\ \text{m s}^{-1}$ at (bearing) 113 **(1)**	**3**	Or consistent with (a)(i) and/or (a)(ii) Accept $d = vt$ provided it is followed by a substitution of the value for displacement. Direction required for final mark. Accept 1-4 sig figs: $0 \cdot 4\ \text{m s}^{-1}$ $0 \cdot 400\ \text{m s}^{-1}$ $0 \cdot 4000\ \text{m s}^{-1}$

Question			Expected response	Max mark	Additional guidance
1.	(c)		$d = \bar{v}t$ **(1)** $37 \cdot 0 = 1 \cdot 25 \times t$ **(1)** $(t = 29 \cdot 6 \text{ s})$ difference in time $= (32 \cdot 5 - 29 \cdot 6)$ $= 2 \cdot 9 \text{s}$ **(1)**	**3**	Accept $s = \bar{v}t$ provided it is followed by a substitution of the value for distance. Accept 1-4 sig figs: 3 s 2·90 s 2·900 s
	(d)		(The forces are) equal (in size) <u>and</u> opposite (in direction).	**1**	Accept: '(the forces are) balanced' Do not accept 'lift equals weight' alone.

MARKS | DO NOT WRITE IN THIS MARGIN

2. A glider is accelerated from rest by a cable attached to a winch.

The graph shows the horizontal velocity v_h of the glider for the first 20 s of its motion.



(a) The glider is accelerated by a constant unbalanced force of 925 N.

(i) Show that the initial acceleration of the glider is $2 \cdot 5$ m s^{-2}. **2**

Space for working and answer

(ii) Calculate the mass of the glider. **3**

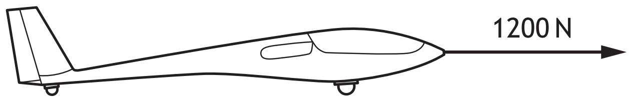
Space for working and answer

* X 8 5 7 7 5 0 1 1 0 *

MARKS | DO NOT WRITE IN THIS MARGIN

2. (a) (continued)

(iii) At 2·0 s the cable pulls the glider with a force of 1200 N.



(A) Determine the size of the frictional forces acting on the glider at this time. **1**

(B) Suggest one design feature of the glider that reduces the frictional forces acting on it. **1**

(b) At 8·0 s the glider reaches its take-off speed and leaves the ground.

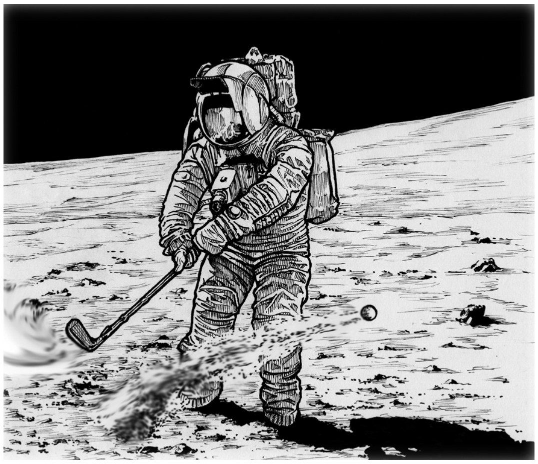
Determine the distance the glider travels along the ground before take-off. **3**

Space for working and answer

Question			Expected response	Max mark	Additional guidance
2.	(a)	(i)	$a=\frac{v-u}{t}$ **(1)** $a=\frac{20-0}{8}$ **(1)** $a=2\cdot5\ \text{ms}^{-2}$	**2**	** SHOW THAT ** Must start with a correct relationship or (0) marks Accept: $a=\frac{\Delta v}{t}$ Do not accept: $a=\frac{v}{t}$ Accept methods starting with: $a=gradient$ or $a=\frac{\Delta y}{\Delta x}$ or $a=\frac{y_2-y_1}{x_2-x_1}$ However substitutions for two points on the line must be shown for the second mark. Accept consistent use of any other values for v, u and t in the first 9·6 s of the graph. Final answer of 2·5 ms^{-2}, including unit, must be shown or MAX (1).
		(ii)	$F=ma$ **(1)** $925=m\times2\cdot5$ **(1)** $m=370$ kg **(1)**	**3**	Must use a value of $2\cdot5\ \text{ms}^{-2}$ for acceleration. Accept 1-4 sig figs: 400 kg 370·0 kg
		(iii) (A)	$(F=1200\text{-}925)$ $F=275$ N	**1**	Ignore any direction stated. Unit must be stated.
		(B)	streamlined (shape) has wheels aerodynamic	**1**	Or any other suitable response. Apply +/- rule for surplus answers
	(b)		$d=area\ under\ graph$ **(1)** $d=\frac{1}{2}\times8\cdot0\times20$ **(1)** $d=80$ m **(1)**	**3**	If incorrect substitution then MAX (1) for (implied) relationship. Accept $s=\bar{v}t$ or $d=\bar{v}t$ for relationship mark. Accept $s=vt$ or $d=vt$, provided substitution of average velocity/ speed is correct. Accept 1-4 sig figs: 80·0 m 80·00 m

MARKS DO NOT WRITE IN THIS MARGIN

3. In 1971, the astronaut Alan Shepard hit a golf ball on the surface of the Moon.

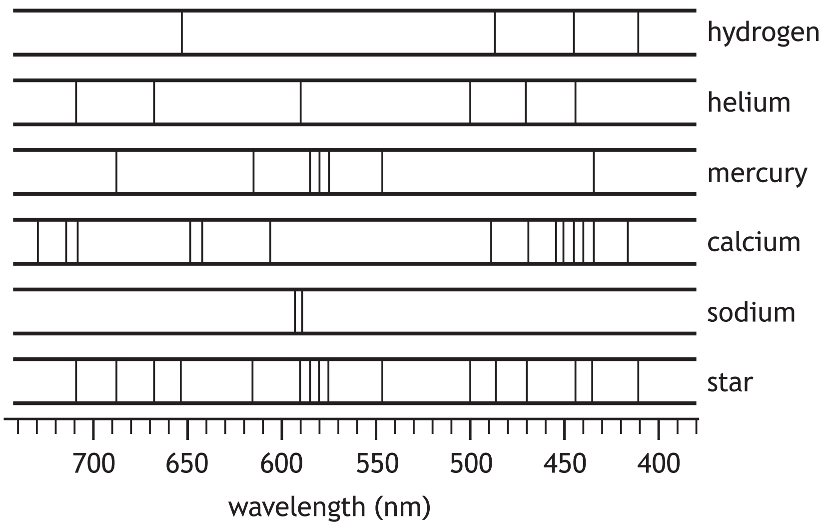


Using your knowledge of physics, comment on the similarities and/or differences between this event and hitting an identical ball on the surface of the Earth. **3**

MARKS DO NOT WRITE IN THIS MARGIN

4. Astronomers studying a distant star analyse the light from the star that reaches Earth.

The line spectrum from the star is shown, along with the line spectra of the elements hydrogen, helium, mercury, calcium, and sodium.



(a) Determine which of these elements are present in the star. **1**

MARKS DO NOT WRITE IN THIS MARGIN

4. (continued)

(b) The star is 97 light-years from Earth.

(i) State what is meant by the term *light-year*. **1**

(ii) Calculate the distance, in metres, from the star to Earth. **3**

Space for working and answer

(c) Astronomers use satellite-based telescopes to collect information about objects in space.

(i) Suggest an advantage of using satellite-based telescopes such as the Hubble Space Telescope. **1**

(ii) State one **other** use of satellites. **1**

* X 8 5 7 7 5 0 1 1 5 *

Question			Expected response	Max mark	Additional guidance
4.	(a)		Hydrogen, helium and mercury	1	Must have all three.
	(b)	(i)	The distance light travels in one year.	1	
		(ii)	$d = vt$ **(1)** $d = 3{\cdot}0 \times 10^8 \times (60 \times 60 \times 24 \times 365{\cdot}25 \times 97)$ **(1)** $d = 9{\cdot}2 \times 10^{17}$ (m) **(1)**	3	Calculation can be carried out in steps, but all steps must be done for the substitution mark to be awarded, eg calculation of distance for one light-year, followed by multiplying this by 97. Unit in final answer not required, but if stated, must be correct. Accept 1-4 sig fig: 9×10^{17} $9{\cdot}18 \times 10^{17}$ $9{\cdot}183 \times 10^{17}$ Also accept, if using 365 days: $9{\cdot}177 \times 10^{17}$
	(c)	(i)	No atmosphere to absorb light full range of EM waves can be observed can be used in cloudy weather/ daytime no light pollution	1	Or other suitable response Do not accept 'closer' but would not negate a correct response. Apply +/- rule for surplus answers
		(ii)	GPS weather forecasting communications scientific discovery	1	Or other suitable response Do not accept responses relating to space observation Apply +/- rule for surplus answers

MARKS | DO NOT WRITE IN THIS MARGIN

5. A student is investigating how the length of a wire affects its resistance.

The student connects different lengths of wire to a power supply of fixed voltage and measures the current in each length of wire.

(a) The measurements taken by the student are shown in the table.

Length of wire (m)	Current (A)
0·20	0·94
0·40	0·66
0·60	0·47
0·80	0·37
1·00	0·32

(i) Using the graph paper, draw a graph of these measurements. **3**

(Additional graph paper, if required, can be found on *page 38*)

MARKS DO NOT WRITE IN THIS MARGIN

5. (a) (continued)

(ii) State whether the resistance of the wire increases, decreases or stays the same, as the length of wire increases.

Justify your answer. 2

(iii) Use your graph to predict the current in a 0·50 m length of wire, when connected to the power supply. 1

(iv) Suggest one way in which the experimental procedure could be improved to give more reliable results. 1

[Turn over

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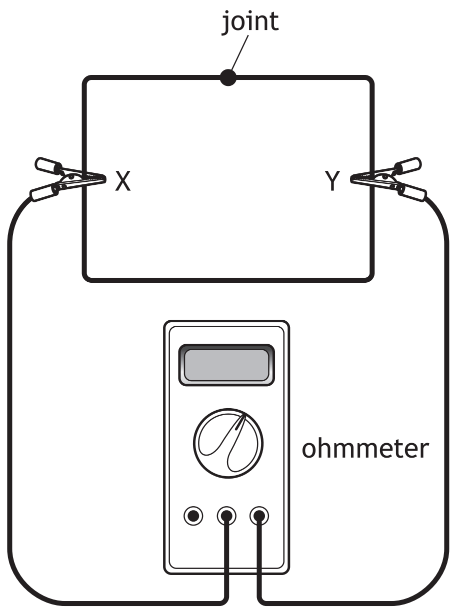
MARKS DO NOT WRITE IN THIS MARGIN

5. (continued)

(b) A length of the wire with a resistance of 5·2 Ω is then folded into a rectangular shape and the ends are joined together.

An ohmmeter is connected across the wire between point X and point Y as shown.



State whether the reading on the ohmmeter would be less than, equal to or greater than 5·2 Ω.

You must justify your answer. **2**

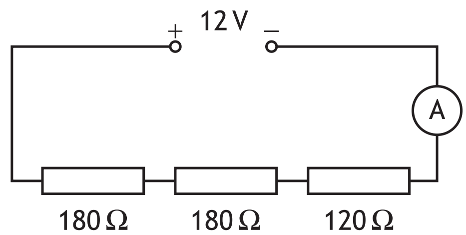
Question			Expected response	Max mark	Additional guidance
5.	(a)	(i)	suitable scales, labels and units **(1)** all points plotted accurately to ± half a division **(1)** best fit curve **(1)**	**3**	A non-linear scale on either axis prevents access to any marks (0). Allow broken axes from origin (with or without symbol)
		(ii)	(Resistance of wire) increases (as the length of wire increases) **(1)** Current decreases (as the length of wire increases). **(1)**	**2**	Effect must be correct, otherwise (0) marks. Can be justified by suitable calculations involving currents from the table/graph.
		(iii)	0·55 A	**1**	**Must** be consistent with candidate's curve or line. Unit required If a candidate has not shown a curve or line in (a)(i) this mark cannot be accessed. If candidate has used a non-linear scale in (a)(i) this mark cannot be accessed.
		(iv)	repeat (and average)	**1**	Accept: • increase the range of lengths • increase the number of different lengths If candidates use the terms 'accurate' and/or 'precise' in their response, they must be used correctly otherwise (0).

Question			Expected response	Max mark	Additional guidance
5.	(b)		(Resistance will be) less (than 5·2 Ω) **(1)** (The wire now has) shorter length (between X and Y) **OR** (Two wires are) connected in parallel **(1)**	**2**	First mark can only be awarded if a justification is attempted. Effect correct + justification correct (2) Effect correct + justification incomplete (1) Effect correct + justification incorrect (wrong physics) (0) Effect correct + no justification attempted (0) Incorrect or no effect stated regardless of justification (0) If candidate tries to justify this by calculation, then the substitution must be correct (R_1 and R_2 are both equal to 2·6 Ω) or (0) marks.

MARKS DO NOT WRITE IN THIS MARGIN

6. A student is investigating connecting different combinations of resistors in circuits.

(a) The student sets up a circuit as shown.



(i) Calculate the current in the circuit. **4**

Space for working and answer

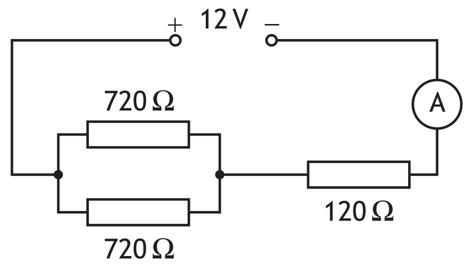
(ii) Calculate the power dissipated in the 120 Ω resistor. **3**

Space for working and answer

MARKS DO NOT WRITE IN THIS MARGIN

6. (continued)

(b) The student then sets up a different circuit as shown.



(i) Determine the total resistance of this circuit. **4**

Space for working and answer

(ii) State how the power dissipated in the 120 Ω resistor in this circuit compares to the power dissipated in the 120 Ω resistor in the circuit in part (a) (ii).

Justify your answer. **2**

Question			Expected response	Max mark	Additional guidance
6.	(a)	(i)	Total $R=180+180+120$ **(1)** $(=480\,\Omega)$ $V=IR$ **(1)** $12=I\times 480$ **(1)** $I=0{\cdot}025$ A **(1)**	**4**	Calculation of resistance may be implied by correct substitution. If no attempt to calculate the resistance, or incorrect substitution to calculate resistance, then MAX (1) for relationship. If clear arithmetic error is shown in the calculation of total resistance then MAX (3). Accept 1-4 sig figs: 0·03 A 0·025 0 A 0·025 00 A For alternative methods: (1) for all required relationships (1) for all substitutions (1) for final answer including unit
		(ii)	$P=I^2R$ **(1)** $P=0{\cdot}025^2\times 120$ **(1)** $P=0{\cdot}075$ W **(1)**	**3**	Or consistent with (a)(i) Accept 1-4 sig figs: 0·08 W 0·075 0 W 0·075 00 W For alternative methods: (1) for all required relationships (1) for all substitutions (1) for final answer including unit
	(b)	(i)	$\frac{1}{R_T}=\frac{1}{R_1}+\frac{1}{R_2}$ **(1)** $\frac{1}{R_T}=\frac{1}{720}+\frac{1}{720}$ **(1)** $(R_T=360\,\Omega)$ $R_{total}=360+120$ **(1)** $R_{total}=480\,\Omega$ **(1)**	**4**	Do not accept wrong relationship eg $\frac{1}{R_T}=\frac{1}{R_1}+\frac{1}{R_2}+R_3$ OR $R_T=\frac{1}{R_1}+\frac{1}{R_2}$ (0) marks If arithmetic error in parallel resistance calculation, can still access mark for adding the 120 Ω resistance, ie MAX (3). If a candidate attempts to calculate all three in parallel (0) marks.
		(ii)	(Power will be) the same **(1)** Current (in the 120 Ω resistor) will be the same **(1)**	**2**	or consistent with (a)(ii) and (b)(i) For justification mark accept: voltage across the 120 Ω resistor will be the same.

MARKS DO NOT WRITE IN THIS MARGIN

7. A hot water dispenser is used to heat enough water for one cup at a time.

The rating plate for the hot water dispenser is shown.

Model: 1-KUPPA
3·5 kW
230 V
50 Hz

The hot water dispenser takes 26 s to heat enough water for one cup.

(a) Show that the energy supplied to the hot water dispenser during this time is 91 000 J. **2**

Space for working and answer

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7. (continued)

(b) The hot water dispenser heats 0·250 kg of water for each cup.

(i) Calculate the minimum energy required to heat 0·250 kg of water from an initial temperature of 20·0 °C to its boiling point. **3**

Space for working and answer

(ii) As the water is dispensed into the cup, steam is released.

Determine the maximum mass of steam that can be produced while the water for one cup is being heated. **4**

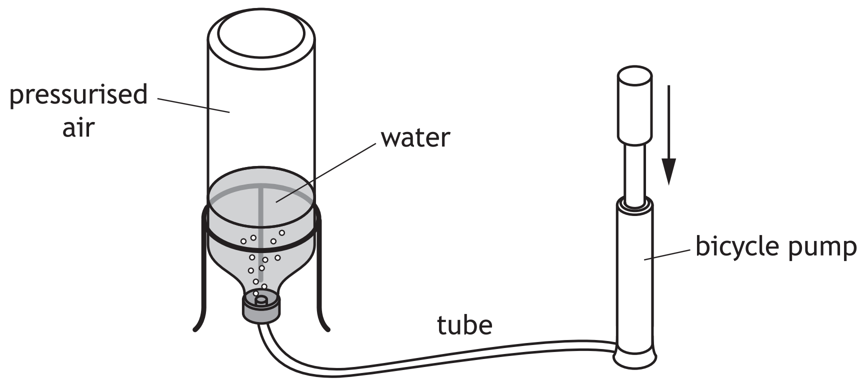
Space for working and answer

(iii) Explain why, in practice, the mass of steam produced is less than calculated in (b)(ii). **1**

Question			Expected response	Max mark	Additional guidance
7.	(a)		$P=\frac{E}{t}$ **(1)** $3500=\frac{E}{26}$ **(1)** $E=91000$ J	**2**	** SHOW THAT ** Must start with a correct relationship or (0) marks Final answer of 91 000 J or its numerical equivalent, including unit, must be shown, otherwise a maximum of (1) can be awarded.
	(b)	(i)	$E_h = cm\Delta T$ **(1)** $=4180\times0\times250\times80\times0$ **(1)** $=83\,600$ J **(1)**	**3**	Accept 2-5 sig figs: 84 000 J
		(ii)	$E_h=91000-83\,600$ **(1)** $(=7400\text{ J})$ $E_h = ml$ **(1)** $7400=m\times22\times6\times10^5$ **(1)** $m=0\times0033$ kg **(1)**	**4**	Or consistent with (b)(i) Calculation of energy difference may be implied by correct substitution. If no attempt to calculate the energy difference, or incorrect substitution to calculate energy difference, then MAX (1) for relationship. If clear arithmetic error is shown in calculation of energy difference then MAX (3). accept: 1–4 sig figs: 0·003 kg 0·003 27 kg 0·003 274 kg
		(iii)	<u>Heat</u> (energy) lost to the surroundings. **OR** Some of the <u>heat</u> (energy) is used to heat the dispenser.	**1**	Accept: not all the <u>heat</u> (energy) is transferred into the water. Do not accept: 'heat loss' alone – it must be clear where it is going.

MARKS | DO NOT WRITE IN THIS MARGIN

8. A water rocket consists of a plastic bottle partly filled with water. Air is pumped in through the water. When the pressure is great enough, the tube detaches from the bottle. Water is forced out of the bottle, which causes the bottle to be launched upwards.

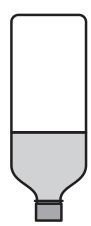


At launch, the air in the bottle is at a pressure of $1{\cdot}74 \times 10^5$ Pa.

(a) On the diagram below, show all the forces acting vertically on the bottle as it is launched.

You must name these forces **and** show their directions. **2**

(An additional diagram, if required, can be found on *page 39*)



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MARKS DO NOT WRITE IN THIS MARGIN

8. (continued)

(b) The area of water in contact with the pressurised air in the bottle is $4{\cdot}50 \times 10^{-3}\,m^2$.

Calculate the force exerted on the water by the pressurised air at launch. **3**

Space for working and answer

(c) At launch, the air in the bottle has a volume of $7{\cdot}5 \times 10^{-4}\,m^3$.

At one point in the flight, the volume of air in the bottle has **increased by** $1{\cdot}2 \times 10^{-4}\,m^3$.

During the flight the temperature of the air in the bottle remains constant.

(i) Calculate the pressure of the air inside the bottle at this point in the flight. **4**

Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

8. (c) (continued)

(ii) Using the kinetic model, explain what happens to the pressure of the air inside the bottle as the volume of the air increases. **3**

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Question			Expected response	Max mark	Additional guidance
8.	(a)		thrust (1)  weight/force of gravity (1)	**2**	Independent marks. Name **and** direction required for each mark. Accept: 'force of water on air in bottle' 'force of water on rocket' Do not accept: 'upward force' alone 'lift (force)' 'upthrust' Accept: 'gravitational pull' 'pull of gravity' Do not accept: 'gravity' alone Apply +/- rule for surplus incorrect forces acting on the bottle for each of the independent marks.
	(b)		$p=\frac{F}{A}$ **(1)** $1{\cdot}74\times10^{5}=\frac{F}{4{\cdot}50\times10^{-3}}$ **(1)** $F=783\text{ N}$ **(1)**	**3**	Accept 2-5 sig figs: 780 N 783·0 N 783·00 N

Question			Expected response	Max mark	Additional guidance
8.	(c)	(i)	New volume of air $=$ $7{\cdot}5\times10^{-4}+1{\cdot}2\times10^{-4}$ **(1)** $\left(8{\cdot}7\times10^{-4}\,\text{m}^3\right)$ $p_1V_1=p_2V_2$ **(1)** $1{\cdot}74\times10^5\times7{\cdot}5\times10^{-4}=p_2\times8{\cdot}7\times10^{-4}$ **(1)** $p_2=1{\cdot}5\times10^5\,\text{Pa}$ **(1)**	4	Calculation of new volume of air may be implied by correct substitution. If no attempt to calculate the new volume, or incorrect substitution to calculate new volume of air, then MAX (1) for relationship. If clear arithmetic error is shown in calculation of new volume of air then MAX (3). Accept 1-4 sig figs: 2×10^5 Pa $1{\cdot}50\times10^5$ Pa $1{\cdot}500\times10^5$ Pa Accept $\frac{p_1V_1}{T_1}=\frac{p_2V_2}{T_2}$ or $\frac{pV}{T}=\text{constant}$
		(ii)	(individual) particles collide with container/walls less frequently (than before) **(1)** (overall) force (on walls) is less **(1)** pressure decreases **(1)**	3	Independent marks. However, if the candidate indicates that individual collisions have less/more force or the particles move slower/faster, then do not award the first mark. Accept ‘atoms’/’molecules’ in place of ‘particles’.

Back to Table

MARKS | DO NOT WRITE IN THIS MARGIN

9. A lifeboat crew is made up of local volunteers. When there is an emergency they have to get to the lifeboat quickly.

The lifeboat crew members are alerted to an emergency using a pager.

Text messages are sent to the pager using radio waves.

(a) The radio waves have a frequency of 153 MHz.

Calculate the wavelength of the radio waves. **3**

Space for working and answer

(b) When the pager receives a message it beeps loudly and a light on the pager flashes.

A crew member holding the pager observes the beeps and the flashes happening at the same time.

A second crew member, who is 100 m away from the pager, also observes the beeps and the flashes.

Explain why the second crew member does not observe the beeps and the flashes happening at the same time. **2**

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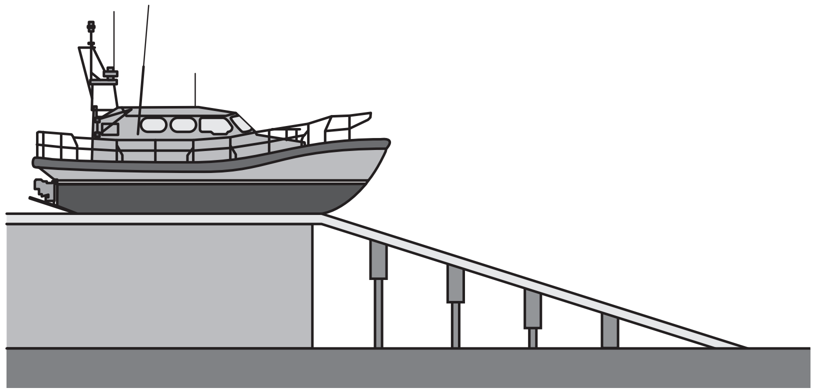
MARKS DO NOT WRITE IN THIS MARGIN

9. (continued)

(c) The lifeboat has a mass of 25 000 kg. When it is launched, it loses $4 \cdot 5 \times 10^5$ J of gravitational potential energy before it enters the water.



(i) Calculate the maximum speed of the lifeboat as it enters the water. **3**

Space for working and answer

(ii) Explain why, in practice, the speed of the lifeboat as it enters the water is less than calculated in (c) (i). **1**

Question			Expected response	Max mark	Additional guidance
9.	(a)		$v = f\lambda$ **(1)** $3{\cdot}0\times10^8 = 153\times10^6\times\lambda$ **(1)** $\lambda = 2{\cdot}0\,\text{m}$ **(1)**	3	Accept 1-4 sig figs: 2 m 1·96 m 1·961 m
	(b)		The speed of light is (much) greater than the speed of sound. **(1)** The sound takes more time to travel (the 100 m). **(1)**	2	Do not accept 'different speeds' alone for first mark. Must make clear which arrives first for the second mark. Any statement that sound travels faster than light (0) marks, otherwise treat as independent marks.
	(c)	(i)	$E_k = \frac{1}{2}mv^2$ **(1)** $4{\cdot}5\times10^5 = 0{\cdot}5\times25000\times v^2$ **(1)** $v = 6{\cdot}0\,\text{ms}^{-1}$ **(1)**	3	Accept 1-4 sig figs: 6 ms^{-1} 6·00 ms^{-1} 6·000 ms^{-1}
		(ii)	energy is lost (as heat and sound) due to friction/air resistance	1	

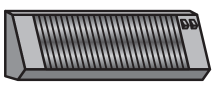
MARKS | DO NOT WRITE IN THIS MARGIN

10. Infrared and gamma rays are both members of a family of waves.

(a) State the name given to this family of waves. **1**

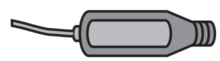
(b) State how the frequency of infrared compares to the frequency of gamma rays. **1**

(c) Some examples of sources and detectors of waves in this family are shown.

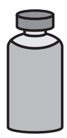


heater

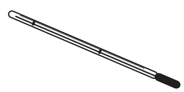
radioactive waste



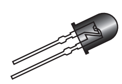
Geiger-Müller tube



fluorescent ink



black-bulb thermometer



LED

(i) From the examples shown, identify

(A) the detector of infrared **1**

(B) the source of gamma rays. **1**

(ii) Suggest one application for the waves that are detected using fluorescent ink. **1**

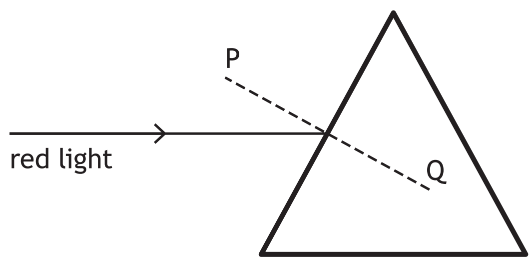
X857750130

Question			Expected response	Max mark	Additional guidance
10.	(a)		electromagnetic (spectrum/waves/radiation)	**1**	Accept: EM (spectrum/waves/radiation)
	(b)		(The frequency of infrared is) less/lower (than the frequency of gamma rays).	**1**	Accept: (The frequency of) gamma (rays) is higher (than the frequency of infrared).
	(c)	(i) (A)	(black-bulb) thermometer	**1**	
		(i) (B)	radioactive waste	**1**	
		(ii)	Treating skin conditions/jaundice Checking security markings on banknotes Produces vitamin D Disinfection of hospital instruments To 'cure' or harden composite material for fillings or nail gel/polish Tanning/Sun-beds	**1**	Any other sensible suggestion Apply +/- rule for surplus answers

MARKS | DO NOT WRITE IN THIS MARGIN

11. A student carries out an experiment to investigate the effect of different shaped glass blocks on the path of a ray of light.

(a) The student directs a ray of red light at a triangular glass block as shown.



(i) Complete the diagram above to show the path of the ray of red light through and out of the glass block. **2**

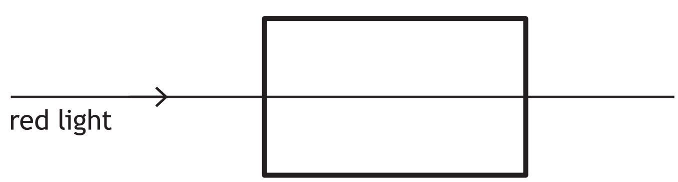
(An additional diagram, if required, can be found on *page 39*)

(ii) The diagram shows a dashed line PQ.

State the name given to this line. **1**

(iii) **On the diagram above**, label an angle of incidence i. **1**

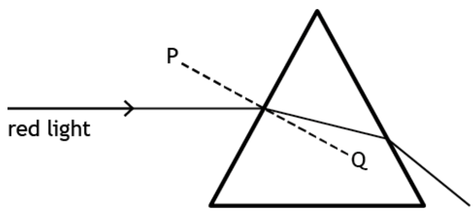
(b) The student replaces the triangular glass block with a rectangular block made of the same material. The path of the ray of red light is as shown.



State whether the wavelength of the red light in this block is less than, the same as, or greater than the wavelength of the red light in the triangular glass block in (a).

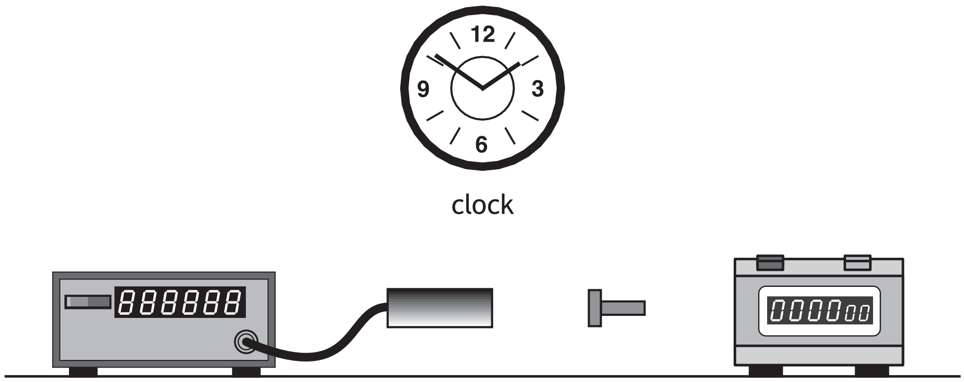
Justify your answer. **2**

X857750131

Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	 correct change in direction on entering block **(1)** correct change in direction leaving the block **(1)**	**2**	Independent marks. Normal not required for ray leaving block. If drawn can be ignored in this part. Arrows not required. Any change of direction of ray within the block then do not award the first mark. Any change of direction of ray after it has left the block then do not award the second mark. Do not accept ray in the block drawn along or below the normal for the first mark.
		(ii)	(the) normal	**1**	
		(iii)	angle of incidence labelled correctly.	**1**	If the angle of incidence is marked on the emergent ray then a second correctly drawn normal is required.
	(b)		(wavelength is the) same **(1)** the blocks are made of the same material. **(1)**	**2**	Effect must be correct otherwise (0) marks. Accept: the blocks have the same optical density the blocks have the same refractive index same amount of refraction takes place the light travels at the same speed in both blocks

MARKS DO NOT WRITE IN THIS MARGIN

12. A technician carries out an experiment, using the apparatus shown, to determine the half-life of a radioactive source.



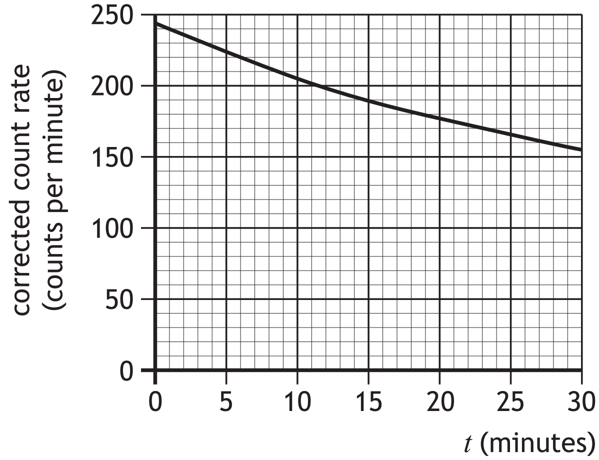
(a) Describe how the apparatus can be used to determine the half-life of the radioactive source. **3**

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

12. (continued)

(b) The technician carries out the experiment over a period of 30 minutes, and displays the data obtained in a graph as shown.



Suggest an improvement that the technician could make to the procedure to more easily determine a value for the half-life of this source. **1**

(c) In a second experiment, the technician absorbs $1 \cdot 2\,\mu J$ of energy throughout their body from a radioactive source.

The mass of the technician is $80 \cdot 0\,kg$.

(i) Calculate the absorbed dose received by the technician. **3**

Space for working and answer

MARKS DO NOT WRITE IN THIS MARGIN

12. (c) (continued)

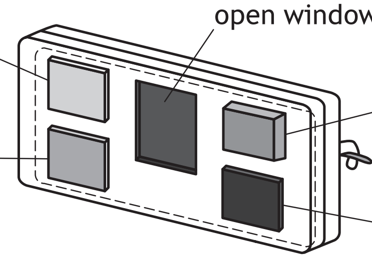
(ii) During the experiment, the technician receives an equivalent dose of $4\cdot5 \times 10^{-8}$ Sv.

Calculate the radiation weighting factor of this source. **3**

Space for working and answer

(d) The technician wears a film badge to monitor exposure to radiation.

The film badge contains a piece of photographic film behind windows of different materials.



Explain how this badge is used to determine the type of radiation the technician has been exposed to. **2**

[Turn over for next question

X857750135

Question			Expected response	Max mark	Additional guidance
12.	(a)		Measure the count in a set time **(1)** Repeat at (regular) intervals **(1)** (Measure and) subtract background (count) **(1)**	**3**	Independent marks Do not accept 'activity' as an alternative to counts in a set time (do not award first mark). Description must refer to the apparatus shown. If a candidate response makes reference to using a ratemeter, then MAX (2) marks. (First mark cannot be awarded.)
	(b)		Carry out experiment over a longer time period.	**1**	
	(c)	(i)	$D=\frac{E}{m}$ **(1)** $D=\frac{1{\cdot}2\times10^{-6}}{80{\cdot}0}$ **(1)** $D=1{\cdot}5\times10^{-8}$ Gy **(1)**	**3**	Accept 1-4 sig figs: 2×10^{-8} Gy $1{\cdot}50\times10^{-8}$ Gy $1{\cdot}500\times10^{-8}$ Gy
		(ii)	$H=Dw_R$ **(1)** $4{\cdot}5\times10^{-8}=1{\cdot}5\times10^{-8}\times w_R$ **(1)** $w_R=3$ **(1)**	**3**	or consistent with (c)(i) Ignore any identification of a type of radiation.
	(d)		(Photographic) <u>film</u> blackened/ darkened/fogged **(1)** (Film behind) different windows affected by different types of radiation **(1)**	**2**	Independent marks Accept: (Photographic) <u>film</u> changes colour For the second mark accept an indication of the absorption/ penetration of radiations by the materials in the windows, however any incorrect statement about the absorption/penetration of a type of radiation means this mark cannot be awarded.

MARKS DO NOT WRITE IN THIS MARGIN

13. A physics teacher makes the following statement.

'Instead of nuclear fission, perhaps one day nuclear fusion will become a practical source of generating energy.'

Using your knowledge of physics, comment on the similarities and/or differences between using nuclear fission and nuclear fusion to generate energy. **3**

[END OF QUESTION PAPER]

X857750136

N5 National Qualifications

X857/75/02

Physics
Section 1 — Questions

Duration — 2 hours 30 minutes

Instructions for the completion of Section 1 are given on *page 02* of your question and answer booklet X857/75/01.

Record your answers on the answer grid on *page 03* of your question and answer booklet.

Reference may be made to the Data sheet on *page 02* of this booklet and to the Relationships sheet X857/75/11.

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

* X 8 5 7 7 5 0 2 *

Back to Table

DATA SHEET

Speed of light in materials

Material	Speed in $m\,s^{-1}$
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	$2{\cdot}3 \times 10^8$

Gravitational field strengths

	Gravitational field strength on the surface in $N\,kg^{-1}$
Earth	9·8
Jupiter	23
Mars	3·7
Mercury	3·7
Moon	1·6
Neptune	11
Saturn	9·0
Sun	270
Uranus	8·7
Venus	8·9

Specific latent heat of fusion of materials

Material	Specific latent heat of fusion in $J\,kg^{-1}$
Alcohol	$0{\cdot}99 \times 10^5$
Aluminium	$3{\cdot}95 \times 10^5$
Carbon Dioxide	$1{\cdot}80 \times 10^5$
Copper	$2{\cdot}05 \times 10^5$
Iron	$2{\cdot}67 \times 10^5$
Lead	$0{\cdot}25 \times 10^5$
Water	$3{\cdot}34 \times 10^5$

Specific latent heat of vaporisation of materials

Material	Specific latent heat of vaporisation in $J\,kg^{-1}$
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	$22{\cdot}6 \times 10^5$

Speed of sound in materials

Material	Speed in $m\,s^{-1}$
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Specific heat capacity of materials

Material	Specific heat capacity in $J\,kg^{-1}\,°C^{-1}$
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Ice	2100
Iron	480
Lead	128
Oil	2130
Water	4180

Melting and boiling points of materials

Material	Melting point in °C	Boiling point in °C
Alcohol	–98	65
Aluminium	660	2470
Copper	1077	2567
Lead	328	1737
Iron	1537	2737
Water	–	100

Radiation weighting factors

Type of radiation	Radiation weighting factor
alpha	20
beta	1
fast neutrons	10
gamma	1
slow neutrons	3
X-rays	1

Back to Table

SECTION 1

Attempt ALL questions

1. Which of the following is a vector quantity?

A force

B distance

C mass

D time

E energy

2. A skydiver falling from an aircraft reaches terminal velocity because

A the air is very thin at high altitude

B there is very little friction acting on the skydiver

C gravitational field strength is less at high altitude

D the skydiver's weight is balanced by air friction

E the skydiver is streamlined.

3. A block of mass 5·0 kg is placed on a smooth, horizontal surface.

Two forces are applied to the block as shown.

The acceleration of the block is

A 0·50 $m\,s^{-2}$

B 2·0 $m\,s^{-2}$

C 3·0 $m\,s^{-2}$

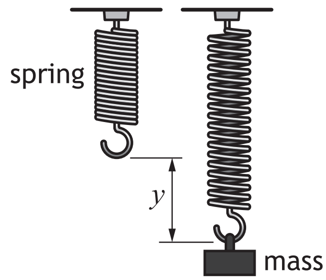
D 5·0 $m\,s^{-2}$

E 8·0 $m\,s^{-2}$.

[Turn over

4. A student designs an experiment to investigate the relationship between the extension y of a spring and the magnitude of the force F applied to it.

Different masses are attached to the spring and the length of the spring is recorded for each mass.



The relationship between F and y is

$$F = ky$$

where k is the spring constant of the spring.

The length of the spring with no mass attached is 0·080 m.

When a mass is attached to the spring, the length of the spring increases to 0·110 m.

The spring constant of the spring is 12 N m^{-1}.

The magnitude of the force applied to the spring is

A 0·0025 N

B 0·36 N

C 1·3 N

D 2·3 N

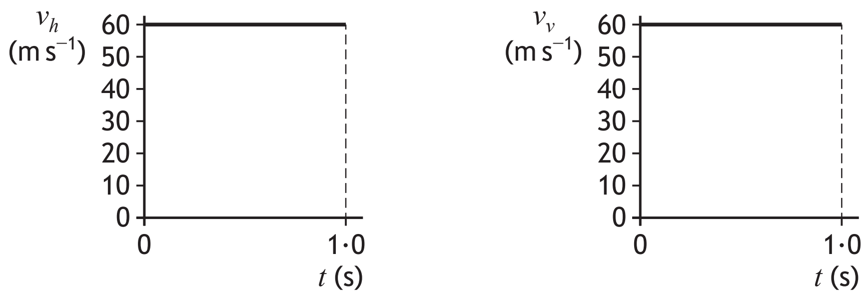
E 400 N.

5. An arrow is fired horizontally with a velocity of 60 m s^{-1}.

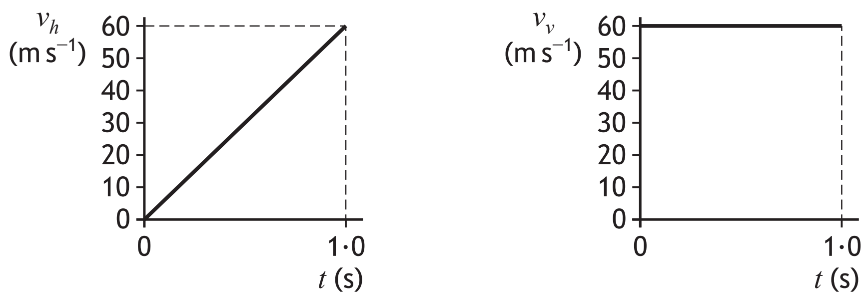
The effects of air resistance on the arrow can be ignored.

Which pair of graphs shows how the horizontal velocity v_h and vertical velocity v_v of the arrow varies with time t during the first second of its flight?

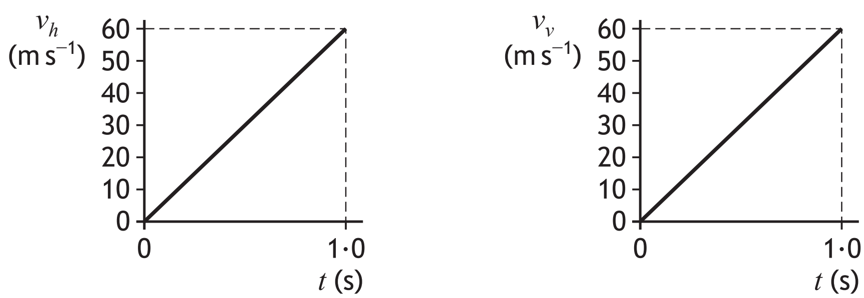
A



B



C



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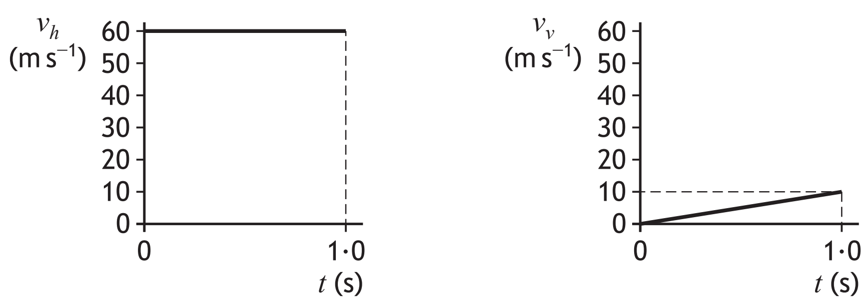
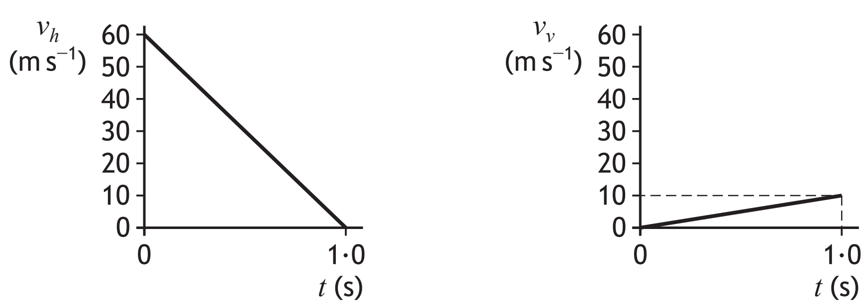


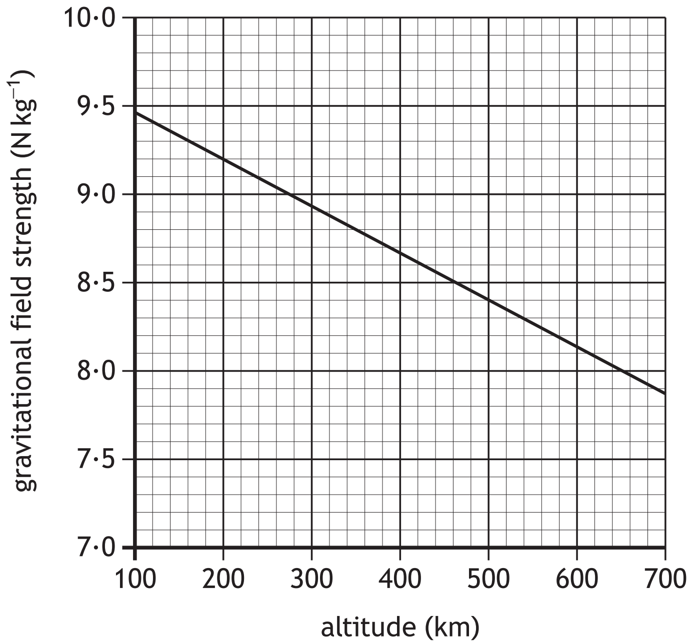
E



[Turn over

6. A satellite orbits the Earth at an altitude of 540 km.

The graph shows how gravitational field strength varies with altitude.



The mass of the satellite is 78 kg.

The weight of the satellite at this altitude is

A 620 N

B 640 N

C 650 N

D 740 N

E 760 N.

7. A student makes the following statements about geostationary satellites in orbit around the Earth.

I The orbital period of a geostationary satellite is 24 hours.

II Geostationary satellites remain above the same point on the Earth's surface.

III Geostationary satellites orbit at different altitudes.

Which of these statements is/are correct?

A I only

B II only

C I and II only

D II and III only

E I, II and III

8. A star is $2 \cdot 4 \times 10^{18}$ m from Earth.

This distance in light-years is

A $3 \cdot 9 \times 10^{-3}$

B $2 \cdot 5 \times 10^{2}$

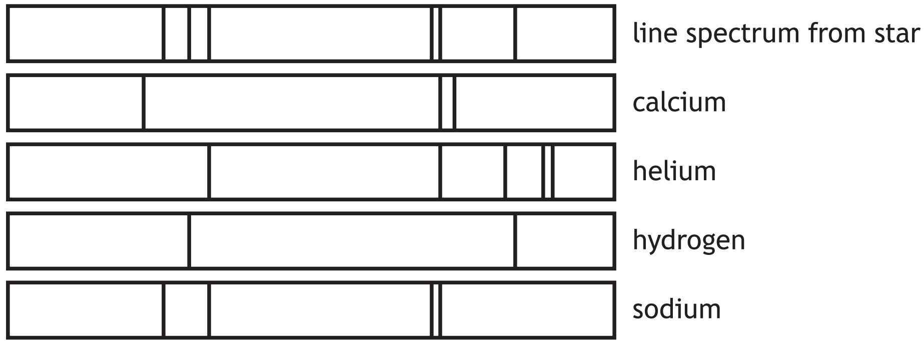
C $1 \cdot 5 \times 10^{4}$

D $8 \cdot 0 \times 10^{9}$

E $9 \cdot 5 \times 10^{15}$.

[Turn over

9. Light from a star is split into a line spectrum of different colours. The line spectrum from the star is shown, along with the line spectra of the elements calcium, helium, hydrogen, and sodium.



The elements present in this star are

A sodium and calcium

B calcium and helium

C hydrogen and sodium

D helium and hydrogen

E calcium, sodium and hydrogen.

10. A heating element is connected to a 12 V supply.

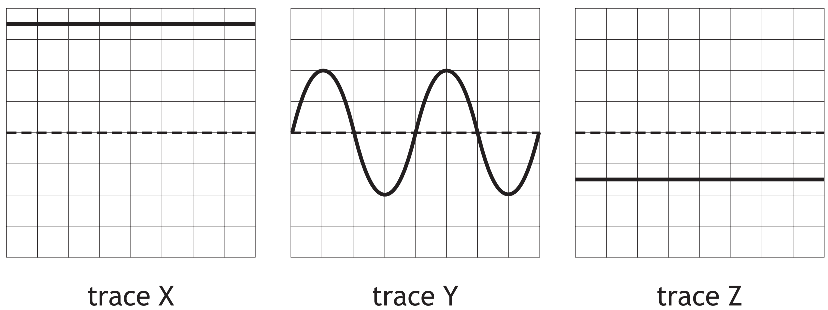
The power rating of the heating element is 48 W.

The charge that passes through the heating element in 5 minutes is

A 0·80 C
B 1·25 C
C 20 C
D 75 C
E 1200 C.

11. An oscilloscope is used to test three different power supplies.

The diagrams represent the traces seen on the screen of the oscilloscope.

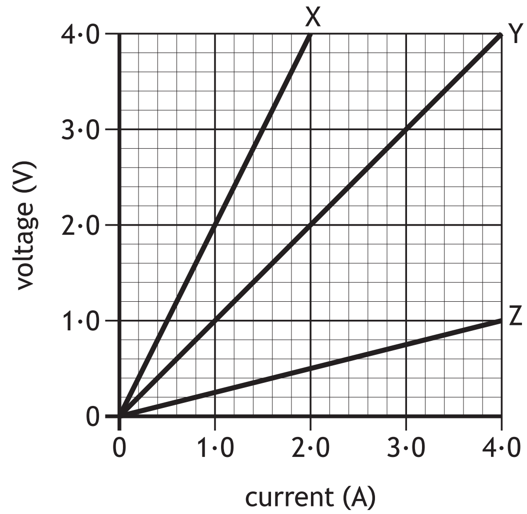


Which of these traces represent a d.c. signal?

A X only
B Y only
C X and Y only
D X and Z only
E X, Y and Z

[Turn over

12. The graph shows how the voltage varies with current for three resistors X, Y and Z.



A student makes the following statements using information from the graph.

I The resistance of resistor X is greater than that of resistors Y and Z.

II When the voltage across resistor Y is 2·0 V, the current in the resistor is 2·0 A.

III The resistance of resistor Z is 0·25 Ω.

Which of these statements is/are correct?

A I only

B II only

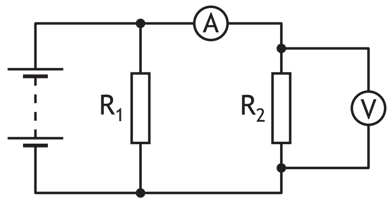
C III only

D II and III only

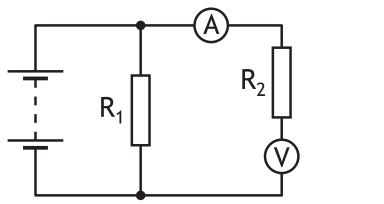
E I, II and III

13. In which of the following circuits would the readings on the meters allow the resistance of R_2 to be calculated?

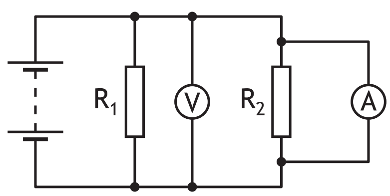
A



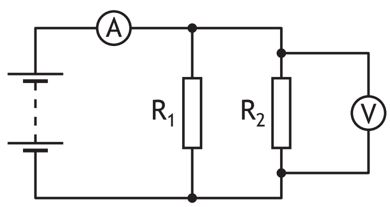
B



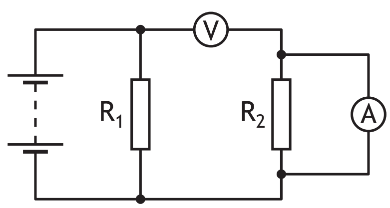
C



D



E

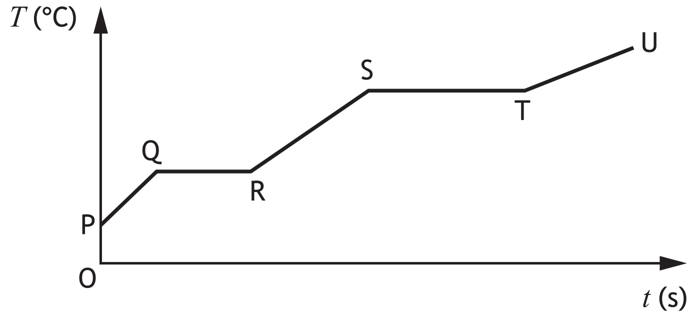


[Turn over

14. A heater is immersed in a substance.

The heater is then switched on.

The graph shows the temperature T of the substance over a period of time t.



Which row in the table identifies the sections of the graph when the substance is changing state from a solid to a liquid and from a liquid to a gas?

	solid to liquid	liquid to gas
A	QR	TU
B	QR	ST
C	PQ	RS
D	PQ	TU
E	ST	QR

15. A sample of water is at a temperature of 100 °C.

The sample absorbs $9{\cdot}0 \times 10^4$ J of energy.

The mass of water changed to steam at 100 °C is

A 0·027 kg

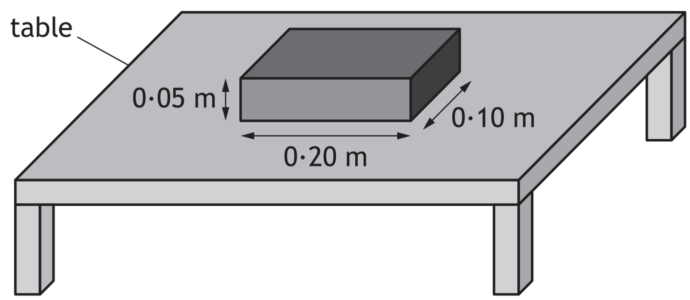
B 0·040 kg

C 0·22 kg

D 22 kg

E 25 kg.

16. A solid rectangular block is placed on a flat, smooth table as shown.



The weight of the block is 28 N.

The pressure exerted on the table by the block is

A 140 Pa

B 280 Pa

C 560 Pa

D 1400 Pa

E 28 000 Pa.

17. A gas is contained inside a sealed syringe.

The volume of the gas in the syringe is decreased.

During this time the temperature of the gas is unchanged.

This change in volume causes the gas particles to

A move faster

B hit the walls of the syringe less often

C move slower

D gain kinetic energy

E hit the walls of the syringe more often.

[Turn over

18. A liquid is heated from 22 °C to 64 °C.

The temperature rise in kelvin is

A 42 K

B 86 K

C 315 K

D 337 K

E 359 K.

19. Five water waves pass a point in a time of 10 seconds.

Which row in the table shows the frequency of the waves and the period of the waves?

	Frequency of the waves (Hz)	**Period of the waves (s)**
A	0·5	2
B	0·5	0·5
C	2	0·5
D	50	0·02
E	50	2

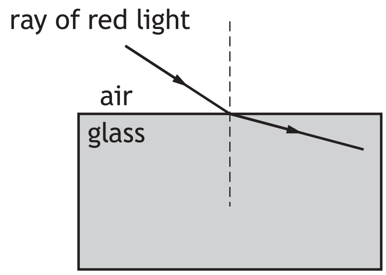
20. A ray of red light travels from air into a glass block.

Which row in the table shows the effect, if any, on the wavelength and speed of the red light as it passes into the glass block?

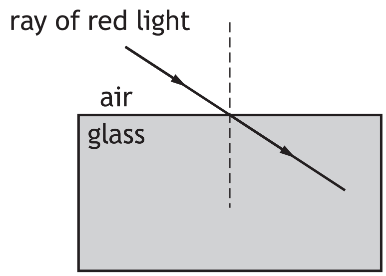
	Wavelength	**Speed**
A	decreases	stays the same
B	stays the same	increases
C	decreases	decreases
D	stays the same	decreases
E	increases	increases

21. Which of the following diagrams shows the path of a ray of red light as it passes from air into a glass block?

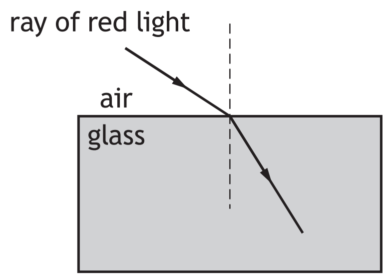
A



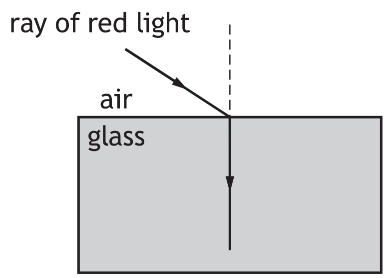
B



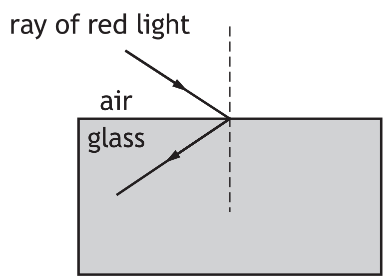
C



D



E

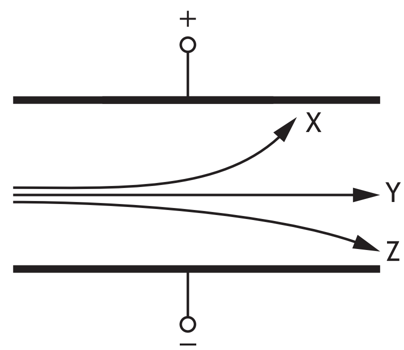


[Turn over

22. A uniform electric field exists between two oppositely charged parallel metal plates.

An alpha particle, a beta particle and a gamma ray each pass between the metal plates.

They follow different paths as shown.



Which row in the table shows the types of radiation that follow paths X, Y and Z?

	Type of radiation that follows path X	Type of radiation that follows path Y	Type of radiation that follows path Z
A	alpha	beta	gamma
B	alpha	gamma	beta
C	beta	alpha	gamma
D	beta	gamma	alpha
E	gamma	alpha	beta

23. During ionisation an atom becomes a positive ion.

Which of the following has been removed from the atom?

A An electron

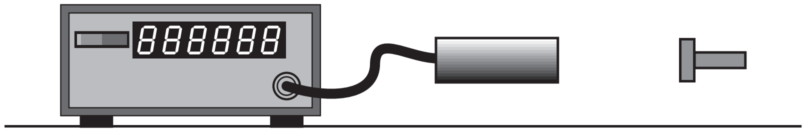
B An alpha particle

C A proton

D A neutron

E A gamma ray

24. A Geiger-Müller tube connected to a counter is placed in front of a radioactive source.



The number of counts recorded in one minute is 3890.

Different shielding materials are now placed in turn between the source and the Geiger-Müller tube, and the number of counts per minute is recorded.

Shielding material	Number of counts per minute
no shielding material	3890
sheet of paper	2110
1 cm of aluminium	2112
5 cm of lead	365

The source is emitting

A alpha radiation only

B beta radiation only

C alpha and beta radiation only

D alpha and gamma radiation only

E beta and gamma radiation only.

25. During radiation treatment, a patient's liver absorbs 90 μJ of gamma radiation.

The mass of the liver is 2·0 kg.

The absorbed dose received by the liver is

A 45 μGy

B 88 μGy

C 90 μGy

D 92 μGy

E 180 μGy.

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET]

Marking Instructions for each question

Section 1

Question	Answer	Mark
1.	A	1
2.	D	1
3.	B	1
4.	B	1
5.	D	1
6.	C	1
7.	C	1
8.	B	1
9.	C	1
10.	E	1
11.	D	1
12.	E	1
13.	A	1
14.	B	1
15.	B	1
16.	D	1
17.	E	1
18.	A	1
19.	A	1
20.	C	1
21.	C	1
22.	D	1
23.	A	1
24.	D	1
25.	A	1

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N5

National Qualifications

Mark

X857/75/01

Physics
Section 1 — Answer grid and Section 2

Duration — 2 hours 30 minutes

X857750 1

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 — 135

SECTION 1 — 25 marks

Attempt ALL questions.

Instructions for 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 X857/75/02 and to the Relationships sheet X857/75/11.

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. 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.

X85775010 1

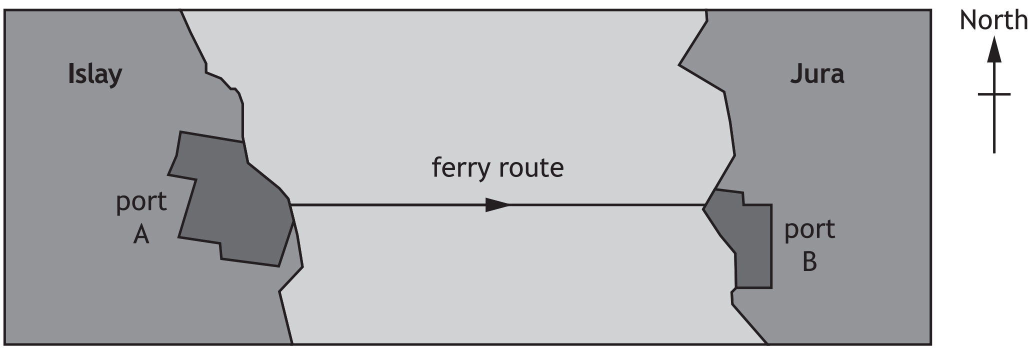
Back to Table

MARKS | DO NOT WRITE IN THIS MARGIN

SECTION 2 — 110 marks

Attempt ALL questions

1. A ferry makes a crossing from port A on the island of Islay to port B on the island of Jura.



Port B is 870 m due East (090) of port A.

(a) The ferry travels directly from port A to port B at an average speed of $2 \cdot 9\ \mathrm{m\,s^{-1}}$.

(i) Calculate the time taken for this crossing. **3**

Space for working and answer

(ii) State the average velocity of the ferry for this crossing. **1**

[Turn over

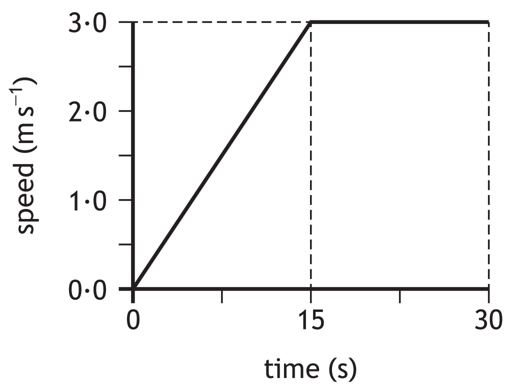
X857750105

Back to Table

MARKS | DO NOT WRITE IN THIS MARGIN

1. (continued)

(b) The graph shows how the speed of the ferry varies during the first 30 s of the crossing.



(i) Determine the acceleration of the ferry during the first 15 s of the crossing. **3**

Space for working and answer

(ii) Determine the distance travelled by the ferry in the first 30 s of the crossing. **3**

Space for working and answer

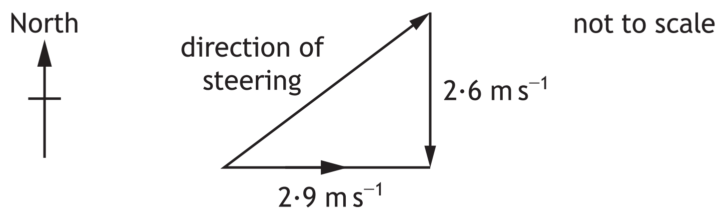
* X 8 5 7 7 5 0 1 0 6 *

MARKS DO NOT WRITE IN THIS MARGIN

1. (continued)

(c) During this crossing a strong current of $2{\cdot}6\ \mathrm{m\,s^{-1}}$ flows due South (180) between the islands.

In order to complete the crossing the ferry must steer against the current as shown.



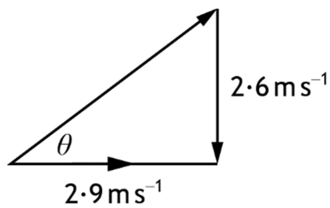
By scale diagram or otherwise, determine the direction the ferry must steer in order to travel directly between port A and B. **2**

Space for working and answer

[Turn over

Section 2

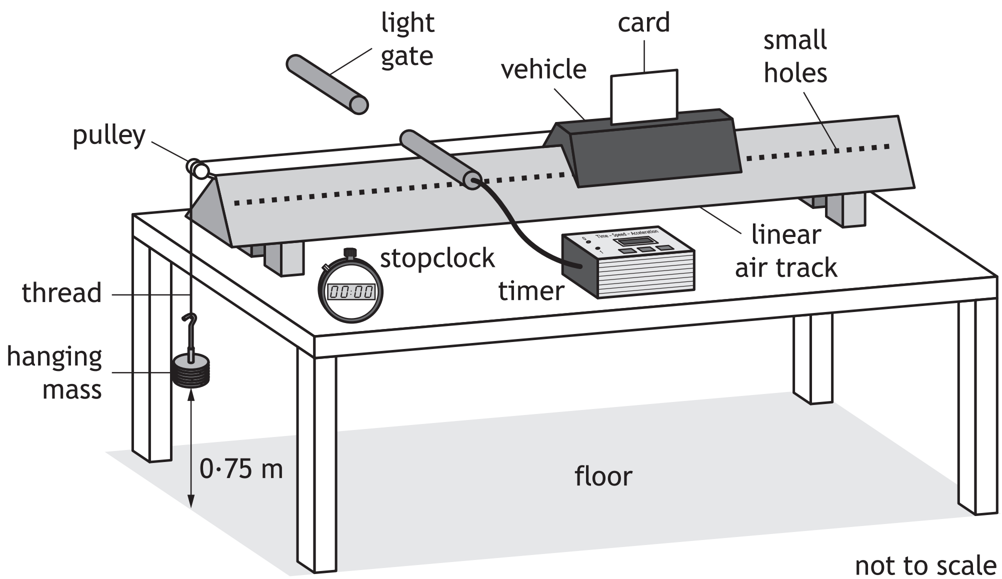
Question			Expected response	Max mark	Additional guidance
1.	(a)	(i)	$d = vt$ **(1)** $870 = 2{\cdot}9 \times t$ **(1)** $t = 300$ s **(1)**	**3**	Accept: 300·0
		(ii)	2·9 m s^{-1} East	**1**	Must have magnitude (including unit) and direction Accept for direction: 090 90° East of North abbreviation E in place of East Do not penalise if degrees symbol is included in three-figure bearings
	(b)	(i)	$a = \frac{v-u}{t}$ **(1)** $= \frac{3{\cdot}0 - 0{\cdot}0}{15}$ **(1)** $= 0{\cdot}20$ m s^{-2} **(1)**	**3**	Accept: $a = \frac{\Delta v}{t}$ or $v = u + at$ Do not accept: $a = \frac{v}{t}$ or $v = at$ Accept: 0·2, 0·200, 0·2000
		(ii)	distance = area under graph **(1)** $= \left(\frac{1}{2} \times 15 \times 3{\cdot}0\right) + (15 \times 3{\cdot}0)$ **(1)** = 68 m **(1)**	**3**	If incorrect substitution then MAX (1) for (implied) relationship Any attempt to use $d = \bar{v}t$ (or $s = \bar{v}t$) applied to the whole graph is wrong physics, award (0) marks. If $d = \bar{v}t$ (or $s = \bar{v}t$) is used for each section of the graph and the results added to give the correct total distance then full marks can be awarded. Accept: 70, 67·5, 67·50

Question			Expected response	Max mark	Additional guidance
1.	(c)		Using scale diagram:  2·6 m s^{-1} θ 2·9 m s^{-1} vectors to scale **(1)** direction = 048 **(1)** (allow ±2° tolerance) **Using trigonometry:** θ = tan^{-1} (2·6/2·9) **(1)** θ = 42° direction = 048 **(1)**	**2**	Accept: 48° E of N 42° N of E Can also do with $\tan^{-1}\left(\frac{2\cdot 9}{2\cdot 6}\right)$ Accept: 50°, 48·1°, 48·12° E of N 40°, 41·9°, 41·88° N of E or as bearings Do not penalise if degrees symbol is included in three-figure bearings

Back to Table

MARKS | DO NOT WRITE IN THIS MARGIN

2. A student sets up an experiment using a linear air track as shown.



A vehicle is mounted on the track.

Air is blown into the track and out through small holes in the sides of the track, causing the vehicle to be lifted slightly above the track.

The vehicle is released from rest and the card mounted on it passes through the light gate.

(a) (i) Explain the purpose of using air to lift the vehicle slightly above the track. **1**

(ii) State the measurements the student must make in this experiment to determine the acceleration of the vehicle. **3**

X857750108

Back to Table

MARKS | DO NOT WRITE IN THIS MARGIN

2. (continued)

(b) The student carries out the experiment using a range of hanging masses.

The results are shown in the table.

Mass of hanging mass (kg)	Weight of hanging mass (N)	Acceleration of vehicle ($m\,s^{-2}$)
0·02	0·20	0·40
0·04	0·39	0·79
0·06	0·59	1·21
0·08	0·78	1·80
0·10	0·98	2·01

The student identifies that one of their values of acceleration needs to be measured again.

State which value of acceleration needs to be measured again.

Justify your answer. **2**

(c) State the main energy change that takes place as the hanging mass falls to the floor. **1**

[Turn over

X857750109

Question			Expected response	Max mark	Additional guidance
2.	(a)	(i)	To reduce friction	**1**	Or similar, as long as the response makes reference to friction
		(ii)	length/width of card **(1)** time for card to pass through the (light) gate **(1)** time taken for card to reach (light) gate **(1)**	**3**	independent marks Do not accept 'vehicle' in place of 'card' Apply the ± rule to additional measurements
	(b)		1·80 ($m\ s^{-2}$) **(1)** acceleration value is not in the same proportion to the accelerating force **(1)**	**2**	The value 1·80 could be indicated on the table e.g. circled, highlighted, 'this one' or similar e.g. it doesn't follow the pattern of going up in steps of 0·4
	(c)		(gravitational) potential to kinetic	**1**	Accept: $E_p \rightarrow E_k$ or E_P to E_k Do not accept: $E_p - E_k$

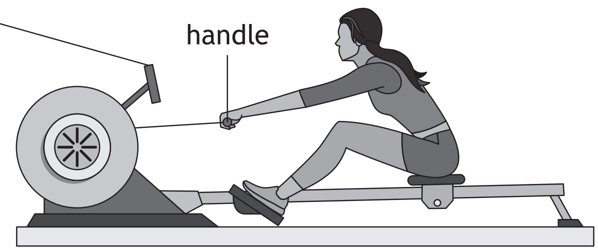
3. An athlete is training on a rowing machine.

Each movement back and forward on the machine is known as a stroke.

The display unit on the machine shows data about the training session.

distance (m)	4560
strokes per minute	27
number of strokes	540
average power (W)	95

display unit



(a) Show that the frequency of the strokes is 0·45 Hz. **2**

Space for working and answer

(b) (i) The athlete trains for 1200 s.

Calculate the energy transferred to the machine by the athlete during this time. **3**

Space for working and answer

MARKS DO NOT WRITE IN THIS MARGIN

3. (b) (continued)

(ii) Explain why, during this time, the athlete produces more energy than that calculated in (b) (i). **1**

(c) During a stroke, the athlete pulls the handle backward through a distance of 1·3 m.

This movement transfers 208 J of energy to the rowing machine.

Calculate the average force exerted on the handle by the athlete during this movement. **3**

Space for working and answer

[Turn over

* X 8 5 7 7 5 0 1 1 1 *

Question			Expected response	Max mark	Additional guidance
3.	(a)		$f=\frac{N}{t}$ **(1)** $=\frac{27}{60}$ **(1)** $=0{\cdot}45$ Hz	2	**'Show' question** Must state the correct relationship or (0) marks Final answer of 0·45 Hz must be shown, otherwise MAX (1) Also accept: $f=\frac{N}{t}$ **(1)** $=\frac{540}{1200}$ **(1)** $=0{\cdot}45$ Hz
	(b)	(i)	$P=\frac{E}{t}$ **(1)** $95=\frac{E}{1200}$ **(1)** $=1{\cdot}1\times10^5$ J **(1)**	3	Accept: 1×10^5 $1{\cdot}14\times10^5$ $1{\cdot}140\times10^5$
		(ii)	Energy will also have been generated as heat/sound	1	Accept: Energy is lost to the surroundings Heat energy produced due to friction or similar
	(c)		$E_w=Fd$ **(1)** $208=F\times1{\cdot}3$ **(1)** $F=160$ N **(1)**	3	Accept: 200, 160·0

MARKS DO NOT WRITE IN THIS MARGIN

4. The table shows information about the moons of the dwarf planet Pluto.

Name	Mass (kg)	Orbital period (days)	Approximate diameter (km)
Charon	$1{\cdot}6 \times 10^{21}$	6·39	1200
Nix	$5{\cdot}0 \times 10^{16}$	24·9	50
Hydra	$5{\cdot}0 \times 10^{16}$	38·2	51
Kerberos	$1{\cdot}6 \times 10^{16}$	32·2	19
Styx	$7{\cdot}5 \times 10^{15}$	20·2	16

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

(b) State which of these moons orbits at the greatest distance from Pluto.

Justify your answer. **2**

(c) On its journey to Pluto, the space probe New Horizons passed close by the planet Jupiter.

Explain how passing close to Jupiter reduced the journey time to Pluto. **2**

MARKS | DO NOT WRITE IN THIS MARGIN

4. (continued)

(d) After passing Jupiter, New Horizons was travelling at a speed of $23{\cdot}0\ \text{km s}^{-1}$.

The mass of New Horizons at this time was 454 kg.

(i) Calculate the kinetic energy of New Horizons at this time. **3**

Space for working and answer

(ii) New Horizons maintained this speed as it travelled on towards Pluto.

Explain, in terms of forces, why New Horizons did not have to use any fuel in order to maintain this speed. **2**

(e) When it reached Pluto, radio signals sent from New Horizons took 4·4 hours to reach Earth.

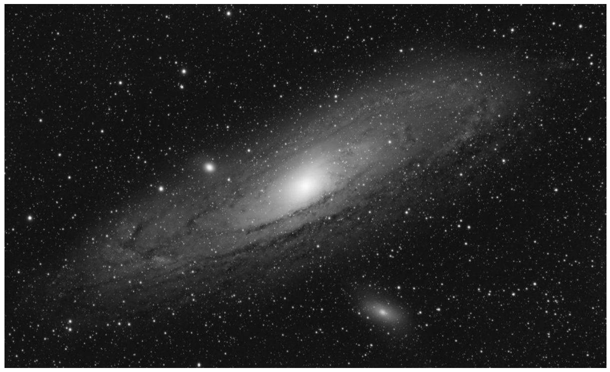
Determine the distance travelled by the signals. **3**

Space for working and answer

Question			Expected response	Max mark	Additional guidance
4.	(a)		A natural satellite of a planet/ dwarf planet	**1**	Do NOT accept: 'satellite of a planet' alone
	(b)		Hydra **(1)** Longest orbital period **(1)**	**2**	
	(c)		It received a gravitational boost/ slingshot/catapult from Jupiter **(1)** (causing) an increase in its speed/kinetic energy **(1)**	**2**	Independent marks
	(d)	(i)	$E_k = \frac{1}{2}mv^2$ **(1)** $= \frac{1}{2} \times 454 \times (23 \cdot 0 \times 10^3)^2$ **(1)** $= 1{\cdot}20 \times 10^{11}\text{J}$ **(1)**	**3**	Accept: $1{\cdot}2 \times 10^{11}$ $1{\cdot}201 \times 10^{11}$ $1{\cdot}2008 \times 10^{11}$
		(ii)	There is no friction/air resistance/ opposing force **(1)** Therefore there is no unbalanced force **(1)**	**2**	Independent marks There are no forces acting against it **(1)** No requirement for any engine force/the engine to be switched on **(1)**
	(e)		$d = vt$ (1) $= 3 \cdot 0 \times 10^8 \times (4 \cdot 4 \times 60 \times 60)$ (1) $= 4 \cdot 8 \times 10^{12}$ m (1)	**3**	Accept: 5×10^{12} $4{\cdot}75 \times 10^{12}$ $4{\cdot}752 \times 10^{12}$

MARKS | DO NOT WRITE IN THIS MARGIN

5. The Andromeda Galaxy is more than 2 million light-years from Earth and is visible with the naked eye. However, there are many astronomical objects that are not visible with the naked eye.



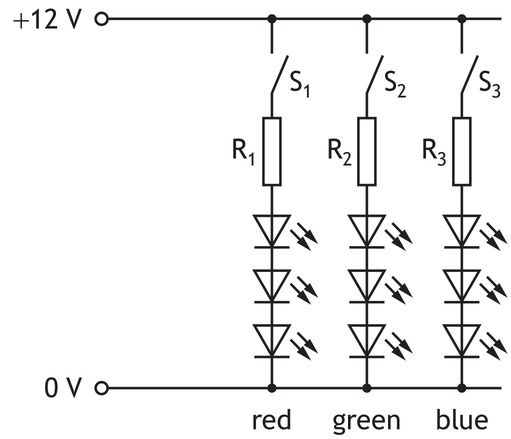
Andromeda Galaxy

Using your knowledge of physics, comment on how astronomers obtain information about astronomical objects. **3**

MARKS | DO NOT WRITE IN THIS MARGIN

6. An LED strip is a long strip of plastic with red, green and blue LEDs placed at regular intervals.

The circuit for one group of LEDs is shown.



(a) Switch S_1 is closed and the red LEDs light.

Each red LED operates at a voltage of 1·8 V and a current of 0·020 A.

(i) State the purpose of the resistor connected in series with the LEDs. **1**

(ii) Determine the resistance of resistor R_1. **4**

Space for working and answer

MARKS DO NOT WRITE IN THIS MARGIN

6. (a) (continued)

(iii) Resistors R_1, R_2 and R_3 have different resistances.

Suggest a reason why different coloured LEDs require different resistances connected in series. **1**

(b) All three switches are now closed.

State whether the red LEDs will be brighter, dimmer or the same brightness compared to when only S_1 is closed.

You must justify your answer. **2**

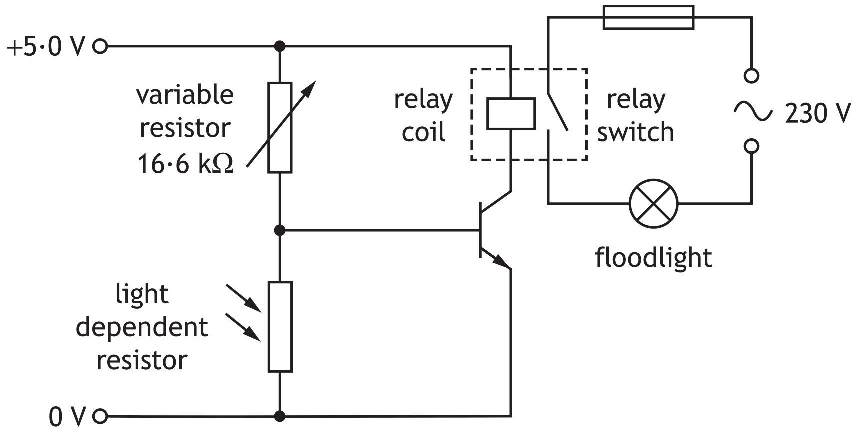
[Turn over

Question			Expected response	Max mark	Additional guidance
6.	(a)	(i)	To reduce/limit the current (in the LEDs)	1	Accept: To reduce the voltage across the LEDs **OR** Protect/prevent damage to the LEDs.
		(ii)	$(V_S = V_R + V_1 + V_2 + V_3)$ $12 = V_R + 1{\cdot}8 + 1{\cdot}8 + 1{\cdot}8$ (1) $(V_R = 6{\cdot}6\text{ V})$ $V_R = IR$ **(1)** $6{\cdot}6 = 0{\cdot}020 \times R$ **(1)** $R = 330\ \Omega$ **(1)**	4	Calculation of voltage across resistor may be implied by correct substitution. If no attempt to calculate the voltage across resistor, or incorrect substitution to calculate the voltage across resistor, then MAX (1) for $V = IR$ relationship. If clear arithmetic error in calculation of voltage across resistor then MAX (3). Accept: 300, 330·0
		(iii)	the green and blue LEDs have different operating voltages/ currents (than the red LEDs)	1	
	(b)		same brightness **(1)** same <u>voltage</u> across the red LEDs **OR** the three branches are connected in parallel, so voltage across them does not change **(1)**	2	First mark can only be awarded if a justification is attempted. Effect correct + justification correct **(2)** Effect correct + justification incomplete **(1)** Effect correct + justification incorrect (wrong physics) **(0)** Effect correct + no justification attempted **(0)** Incorrect or no effect stated regardless of justification **(0)** Accept: dimmer (1) provided supported by justification relating to lost volts/internal resistance. (1) Justifications that relate to the supply voltage not changing alone, would be considered incomplete.

MARKS | DO NOT WRITE IN THIS MARGIN

7. A security floodlight is used to automatically illuminate an area outside a building when it gets dark.

The circuit for this system is shown.



The resistance of the variable resistor is set to 16·6 kΩ.

The transistor in this circuit has a switch on voltage of 0·7 V.

(a) The light level decreases to the point where the resistance of the light dependent resistor is 3·4 kΩ.

Show by calculation that the transistor is switched on at this light level. **3**

Space for working and answer

MARKS DO NOT WRITE IN THIS MARGIN

7. (continued)

(b) The floodlight is connected in a part of the circuit controlled by a relay.

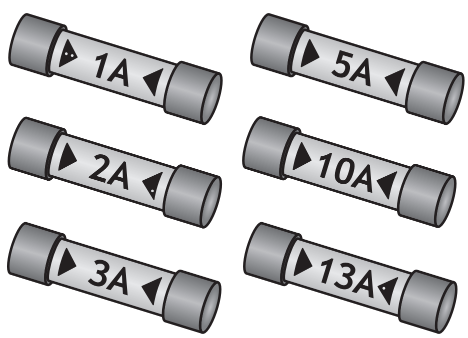
(i) Explain why a relay is used in the circuit. **1**

(ii) The floodlight has a power rating of 575 W.

Calculate the current in the floodlight when it is switched on. **3**

Space for working and answer

(iii) The following fuses are available for use with the floodlight.



State which of these fuses is the most appropriate for use with the floodlight. **1**

[Turn over

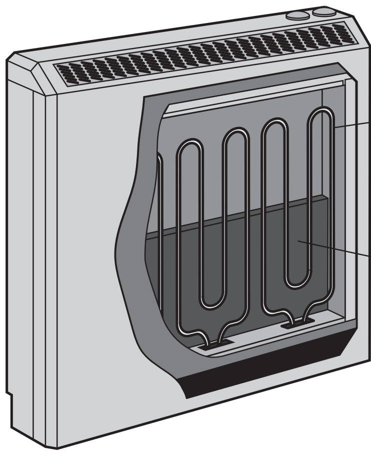
Back to Table

Question			Expected response	Max mark	Additional guidance
7.	(a)		$V_2 = \frac{R_2}{R_1 + R_2} V_s$ **(1)** $V_2 = \frac{3400}{16\,600 + 3400} \times 5{\cdot}0$ **(1)** $V_2 = 0{\cdot}85\ \text{V}$ **(1)** (which is greater than 0·7 V)	**3**	Method 2: $V = IR$ $5{\cdot}0 = I \times (16\,600 + 3400)$ $(I = 2{\cdot}5 \times 10^{-4})$ $V = IR$ $= 2{\cdot}5 \times 10^{-4} \times 3400$ $= 0{\cdot}85\ \text{V}$ (1) mark for Ohm's Law (even if only seen once) (1) mark for all substitutions (1) mark for final answer including unit Method 3: $\frac{V_1}{V_2} = \frac{R_1}{R_2}$ (1) $\frac{V_1}{5{\cdot}0} = \frac{3400}{(16\,600 + 3400)}$ (1) $V_1 = 0{\cdot}85\ \text{V}$ (1) Resistances may be kept in kΩ in all methods Accept: 0·9, 0·850, 0·8500
	(b)	(i)	The control circuit operates at 5 V, the floodlight at 230 V.	**1**	Accept: The two parts of the circuit operate at different voltages. The floodlight requires a higher current than can be supplied in the transistor circuit.
		(ii)	$P = IV$ **(1)** $575 = I \times 230$ **(1)** $= 2{\cdot}5\ \text{A}$ **(1)**	**3**	Accept: 3, 2·50, 2·500
		(iii)	3 A	**1**	Or consistent with 7 (b)(ii)

Back to Table

MARKS | DO NOT WRITE IN THIS MARGIN

8. A storage heater heats a material overnight then allows the material to radiate this heat during the day.



A manufacturer is testing heat storage materials with different specific heat capacities.

In each test the temperature of 2·5 kg of material is raised from 22 °C to 250 °C.

(a) One of the materials being tested by the manufacturer is clay brick.

Clay brick has a specific heat capacity of 810 $J\,kg^{-1}\,°C^{-1}$.

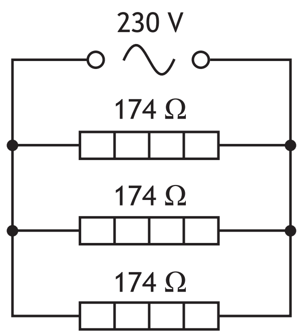
Calculate the minimum energy required to heat 2·5 kg of clay brick from 22 °C to 250 °C. **3**

Space for working and answer

8. (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(b) The circuit for the heating elements in the storage heater is shown.



(i) Calculate the total resistance of the circuit. **3**

Space for working and answer

(ii) Calculate the total power developed in the circuit. **3**

Space for working and answer

(c) The manufacturer repeats the test using oil instead of clay brick.

State whether the time taken to heat the oil is less than, equal to or greater than the time to heat the clay brick.

Justify your answer. **2**

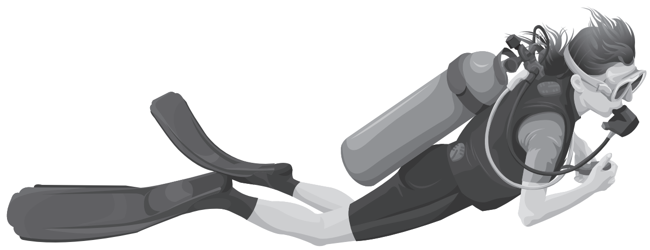
X857750121

Question			Expected response	Max mark	Additional guidance
8.	(a)		$E_h = cm\Delta T$ **(1)** $E_h = 810 \times 2{\cdot}5 \times (250 - 22)$ **(1)** $E_h = 4{\cdot}6 \times 10^5$ J **(1)**	**3**	Calculation of temperature change may be implied by correct substitution. If no attempt to calculate the temperature change or incorrect substitution to calculate the temperature change then MAX (1) for relationship. If clear arithmetic error in calculation of temperature change then MAX (2). Accept: 5×10^5 $4{\cdot}62 \times 10^5$ $4{\cdot}617 \times 10^5$
	(b)	(i)	$\frac{1}{R_T}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$ **(1)** $\frac{1}{R_T}=\frac{1}{174}+\frac{1}{174}+\frac{1}{174}$ **(1)** $R_T = 58{\cdot}0\,\Omega$ **(1)**	**3**	If wrong equation used eg $R_T = \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$ then (0) marks Accept imprecise working towards a final answer $\frac{1}{R_T}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}=\frac{1}{174}+\frac{1}{174}+\frac{1}{174}=58{\cdot}0\,\Omega$ accept Accept 'product over sum' method, provided it is done correctly for all three resistances. Accept: 58, 58·00, 58·000
		(ii)	$P=\frac{V^2}{R}$ **(1)** $P=\frac{230^2}{58{\cdot}0}$ **(1)** $P=910\,\mathrm{W}$ **(1)**	**3**	Or consistent with (b)(i) Accept alternative methods using both $V = IR$ and $P = IV$ or $P = I^2R$ (1) mark for both relationships (1) mark for all substitutions including accounting for currents/powers for all three branches, if worked out for each individual branch (1) mark for final answer including unit Accept: 900, 912, 912·1

Question			Expected response	Max mark	Additional guidance
8.	(c)		greater time **(1)** specific heat capacity (of oil) is greater (than clay brick) **(1)**	**2**	

MARKS | DO NOT WRITE IN THIS MARGIN

9. A scuba diver uses compressed air from a cylinder to breathe underwater.



(a) When the cylinder is full, the volume of compressed air in the cylinder is equivalent to 960 litres of air at a pressure of $2 \cdot 5 \times 10^5$ Pa.

The cylinder has a fixed volume of 12 litres.

Show that the pressure inside a full cylinder is $2 \cdot 0 \times 10^7$ Pa. **2**

Space for working and answer

X857750122

MARKS DO NOT WRITE IN THIS MARGIN

9. (continued)

(b) A full cylinder containing air at a pressure of $2{\cdot}0 \times 10^7$ Pa is stored at a temperature of 21 °C before the dive.

When the cylinder is submerged in the water, the temperature of the air in the cylinder reduces to the temperature of the water.

This causes the pressure of the air in the full cylinder to reduce to $1{\cdot}9 \times 10^7$ Pa.

(i) Calculate the temperature of the water. **3**

Space for working and answer

(ii) Using the kinetic model, explain why the pressure of the gas inside the full cylinder decreases as the temperature decreases. **3**

[Turn over

X857750123

Question			Expected response	Max mark	Additional guidance
9.	(a)		$p_1V_1 = p_2V_2$ **(1)** $p_1 \times 12 = 2 \cdot 5 \times 10^5 \times 960$ **(1)** $p_1 = 2 \cdot 0 \times 10^7$ Pa	**2**	SHOW question Must start with a correct relationship or (0) marks. Final answer of $2{\cdot}0 \times 10^7$ Pa or its numerical equivalent including unit must be shown otherwise a maximum of (1) can be awarded. Accept use of $pV =$ constant for the relationship
	(b)	(i)	$\frac{p_1}{T_1} = \frac{p_2}{T_2}$ **(1)** $\frac{2 \cdot 0 \times 10^7}{294} = \frac{1 \cdot 9 \times 10^7}{T_2}$ **(1)** $T_2 = 280$ K **(1)**	**3**	Substitution of temperature in °C MAX (1) mark for relationship. Accept: $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$ (1) $\frac{2 \cdot 0 \times 10^7 \times 12}{294} = \frac{1 \cdot 9 \times 10^7 \times 12}{T_2}$ (1) $T_2 = 280$ K (1) Accept: 300, 279, 279·3 Accept correct answer expressed in °C
		(ii)	(The decrease in temperature) decreases the kinetic energy of the gas particles/the particles move slower. **(1)** The particles hit the walls of the container less often/frequently. **(1)** The particles hit the walls of the container with less force. **(1)** (since $p = \frac{F}{A}$ and A is constant, the pressure decreases)	**3**	Independent marks Accept: 'atoms'/'molecules' in place of 'particles' Do not accept: 'particles hit the container/walls less' alone.

Back to Table

MARKS | DO NOT WRITE IN THIS MARGIN

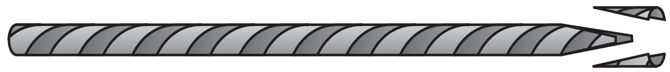
10. Electric vehicles are being promoted as an environmentally friendly method of transport.

Currently one of the limitations of electric vehicles is their range. The range is the maximum distance that an electric vehicle can travel before its batteries need to be recharged.

Using your knowledge of physics comment on possible factors affecting the range of an electric vehicle. **3**

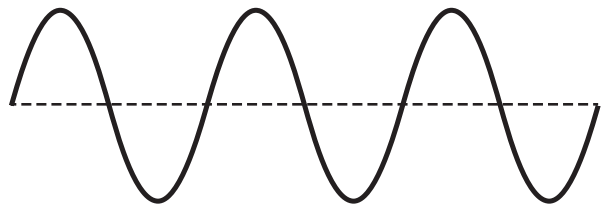
MARKS | DO NOT WRITE IN THIS MARGIN

11. A student investigating sound cuts a drinking straw as shown.



(a) The student blows through the straw to produce a sound.

A microphone is connected to an oscilloscope. The oscilloscope displays a trace of the sound wave produced by the straw as shown.



On the trace, draw **and** label

(i) the amplitude **1**

(ii) the wavelength, λ. **1**

(An additional diagram, if required, can be found on *page 35*.)

(b) The sound produced has a frequency of 250 Hz.

Calculate the wavelength of the sound in air. **3**

Space for working and answer

[Turn over

* X 8 5 7 7 5 0 1 2 7 *

11. (continued)

(c) The student carries out an experiment to investigate how the length of the straw affects the frequency of the sound produced.

The results of this experiment are as shown.

Length of straw (mm)	Frequency (Hz)
20	1204
40	597
60	420
80	282
100	250

(i) Using the graph paper below, draw a graph of these results. **3**

(Additional graph paper, if required, can be found on *page 35*.)

MARKS DO NOT WRITE IN THIS MARGIN

11. (c) (continued)

(ii) Use your graph to predict the frequency of sound produced by a straw that is 30 mm in length. **1**

(iii) Suggest one change that could be made to improve the reliability of this experiment. **1**

[Turn over

X857750129

Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	Amplitude correctly indicated and labelled	**1**	
		(ii)	Wavelength correctly indicated and labelled	**1**	
	(b)		$v = f\lambda$ **(1)** $340 = 250 \times \lambda$ **(1)** $\lambda = 1{\cdot}4$ m **(1)**	**3**	Accept:1, 1·36, 1·360
	(c)	(i)	Suitable scales, labels and units **(1)** All points plotted accurately to ± half a division **(1)** Best fit <u>curve</u> **(1)**	**3**	A non-linear scale on either axis prevents access to any marks (0) Allow broken axes from origin (with or without symbol), but scale must be linear across data range. A bar chart can obtain MAX (1) for scales, labels and units. Axes can be transposed.
		(ii)	800 Hz	**1**	**Must** be consistent with the line the candidate has drawn. ± half a division tolerance If the candidate has not shown a curve or line in (c)(i) this mark cannot be accessed. If the candidate has used a non-linear scale in (c)(i) this mark cannot be accessed.
		(iii)	Repeat (measurements and average) **(1)**	**1**	Accept: • Increase the range of lengths. • Increase the number of different lengths. If candidates use the term 'accurate' and/or 'precise' in their response, they must be used correctly, otherwise (0)

12. A scientist studying human genetics uses a technique involving a radioactive tracer called a DNA probe.

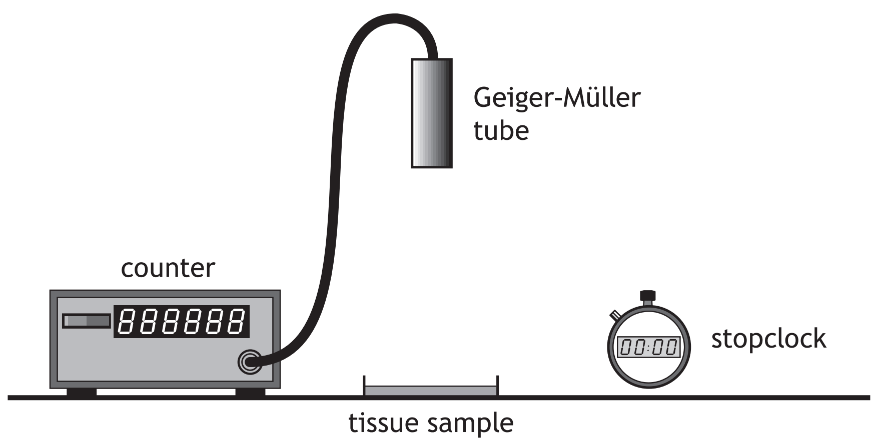
The DNA probe allows the scientist to identify if a particular section of DNA is present within a sample of tissue.

(a) The scientist prepares a solution containing the DNA probe and labels it as shown.

DNA Probe Solution
Date prepared: Monday 20 April 2020 Half-life: 22 hours Radiation emitted: Beta particles

Suggest why this solution would be unsuitable to use one week after it was prepared. **1**

(b) The scientist uses the equipment shown to test a tissue sample to identify if the DNA probe is present.



The average background count rate is 18 counts per minute.

MARKS DO NOT WRITE IN THIS MARGIN

12. (b) (continued)

(i) State a source of background radiation. **1**

(ii) The tissue sample has an activity of 5·5 Bq.

Calculate the number of decays that occur in this sample each minute. **3**

Space for working and answer

(iii) In practice, the number of decays per minute detected by the Geiger-Müller tube is much less than the number of decays calculated in (b) (ii).

This makes it difficult to distinguish the count rate due to the DNA probe from that due to background radiation.

Suggest one change to the set up that would increase the number of decays per minute detected by the Geiger-Müller tube due to the DNA probe in this sample. **1**

[Turn over

Question			Expected response	Max mark	Additional guidance
12.	(a)		Activity (of DNA probe/solution) decreases too much with the time (to still be suitable)	**1**	Accept: Activity will be too low after a week Not enough beta particles per second/unit time will be emitted to be detected, after one week Do not accept radioactivity in place of activity Do not accept answers relating to short half-life alone
	(b)	(i)	Any suitable source	**1**	Apply ± rule for surplus answers Do not accept: cosmic microwave background radiation
		(ii)	$A = \frac{N}{t}$ **(1)** $5{\cdot}5 = \frac{N}{60}$ **(1)** $N = 330$ (decays) **(1)**	**3**	
		(iii)	Move the Geiger-Müller tube closer (to the tissue sample).	**1**	Accept: Place shielding around apparatus

MARKS | DO NOT WRITE IN THIS MARGIN

13. In a nuclear power station, nuclear reactions are used to generate electrical energy.

(a) In a nuclear reaction a uranium nucleus is split by a neutron to produce two smaller nuclei, two or three neutrons and energy.

(i) State the name given to this type of nuclear reaction. **1**

(ii) Explain how a single reaction can lead to the continuous generation of energy. **2**

13. (continued) MARKS DO NOT WRITE IN THIS MARGIN

(b) The waste products from nuclear power stations are radioactive and need to be stored until their activity reaches a safe level.

One type of waste has a half-life of 32 years.

Determine the time taken for the activity of this waste to decrease to one eighth of its original value. **3**

Space for working and answer

(c) During a typical shift, a worker handling radioactive material receives an absorbed dose of 2·2 μGy from slow neutrons and 3·4 μGy from gamma radiation.

(i) Determine the total equivalent dose received by the worker during a typical shift. **4**

Space for working and answer

(ii) The annual dose limit for a radiation worker is 20 mSv.

Determine the number of typical shifts that it would take for the worker to receive a dose of 20 mSv. **2**

Space for working and answer

[END OF QUESTION PAPER]

X857750133

Question			Expected response	Max mark	Additional guidance
13.	(a)	(i)	(induced nuclear) fission	**1**	
		(ii)	The neutrons produced in first reaction can go on to cause further reactions/split more nuclei **(1)** this process repeats/a chain reaction occurs. **(1)**	**2**	Independent marks. Accept: 'hit'/'collides' If a candidate indicates that a single nucleus repeatedly splits award (0) marks.
	(b)		1 -> ½ -> ¼ -> ⅛ evidence of halving **(1)** 3 half-lives **(1)** 96 years **(1)**	**3**	Final answer must have appropriate unit.
	(c)	(i)	$H = Dw_r$ **(1)** $H = 2 \cdot 2 \times 10^{-6} \times 3$ **(1)** $(= 6 \cdot 6 \times 10^{-6}\ \text{Sv})$ $H = 3 \cdot 4 \times 10^{-6} \times 1$ **(1)** $(= 3 \cdot 4 \times 10^{-6}\ \text{Sv})$ $H_{total} = 1 \cdot 0 \times 10^{-5}\ \text{Sv}$ **(1)**	**4**	Acceptable to carry out calculations using μGy Unit for final answer must be sieverts (or μSv, etc) Accept: 1×10^{-5} $1 \cdot 00 \times 10^{-5}$ $1 \cdot 000 \times 10^{-5}$
		(ii)	$N = \dfrac{20 \times 10^{-3}}{1 \cdot 0 \times 10^{-5}}$ **(1)** $N = 2000$ (shifts) **(1)**	**2**	Or consistent with (c)(i)

[END OF MARKING INSTRUCTIONS]

N5 National Qualifications 2022

X857/75/02

Physics
Section 1 — Questions

FRIDAY, 13 MAY

1:00 PM – 3:30 PM

Instructions for the completion of Section 1 are given on *page 02* of your question and answer booklet X857/75/01.

Record your answers on the answer grid on *page 03* of your question and answer booklet.

Reference may be made to the Data Sheet on *page 02* of this booklet and to the Relationship Sheet X857/75/11.

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

X85775O2

A/PB

Back to Table

DATA SHEET

Speed of light in materials

Material	Speed in m s^{-1}
Air	3.0×10^8
Carbon dioxide	3.0×10^8
Diamond	1.2×10^8
Glass	2.0×10^8
Glycerol	2.1×10^8
Water	2.3×10^8

Gravitational field strengths

	Gravitational field strength on the surface in N kg^{-1}
Earth	9.8
Jupiter	23
Mars	3.7
Mercury	3.7
Moon	1.6
Neptune	11
Saturn	9.0
Sun	270
Uranus	8.7
Venus	8.9

Specific latent heat of fusion of materials

Material	Specific latent heat of fusion in J kg^{-1}
Alcohol	0.99×10^5
Aluminium	3.95×10^5
Carbon Dioxide	1.80×10^5
Copper	2.05×10^5
Iron	2.67×10^5
Lead	0.25×10^5
Water	3.34×10^5

Specific latent heat of vaporisation of materials

Material	Specific latent heat of vaporisation in J kg^{-1}
Alcohol	11.2×10^5
Carbon Dioxide	3.77×10^5
Glycerol	8.30×10^5
Turpentine	2.90×10^5
Water	22.6

Speed of sound in materials

Material	Speed in m s^{-1}
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Specific heat capacity of materials

Material	Specific heat capacity in J kg^{-1} °C^{-1}
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Ice	2100
Iron	480
Lead	128
Oil	2130
Water	4180

Melting and boiling points of materials

Material	Melting point in °C	Boiling point in °C
Alcohol	–98	65
Aluminium	660	2470
Copper	1077	2567
Lead	328	1737
Iron	1537	2737
Water	–	100

Radiation weighting factors

Type of radiation	Radiation weighting factor
alpha	20
beta	1
fast neutrons	10
gamma	1
slow neutrons	3
X-rays	1

Back to Table

SECTION 1 — 25 marks

Attempt ALL questions

1. Which of the following contains one scalar quantity and one vector quantity?

A acceleration; displacement

B kinetic energy; speed

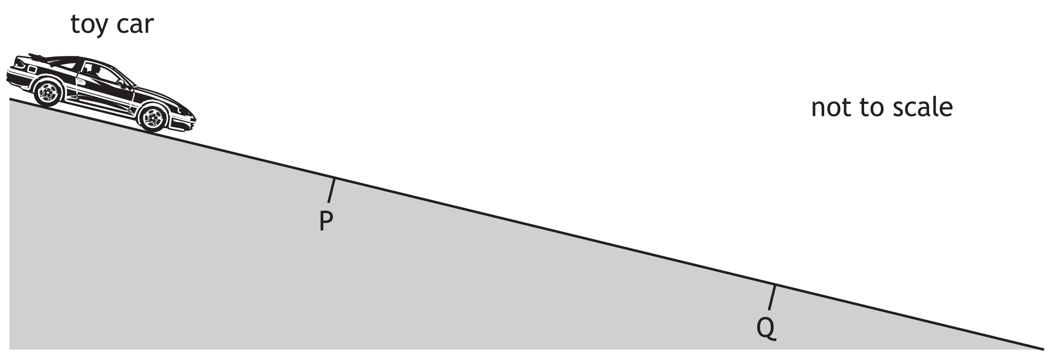
C velocity; weight

D potential energy; work

E distance; force

2. The diagram shows a toy car at rest at the top of a slope.

The car is released and travels with a constant acceleration down the slope.

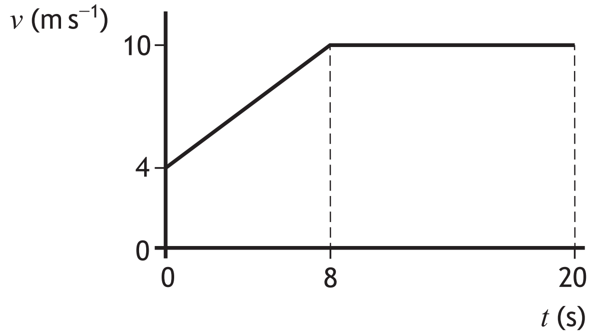


Which row in the table could show the speed of the toy car at P, the speed of the toy car at Q, and the average speed of the car between P and Q?

	Speed at P ($m\,s^{-1}$)	Speed at Q ($m\,s^{-1}$)	Average speed between P and Q ($m\,s^{-1}$)
A	0	2	1
B	1	1	1
C	1	3	2
D	2	3	2
E	2	3	4

[Turn over

3. The graph of speed v against time t represents the motion of a cyclist over a 20 second period.



The distance travelled by the cyclist in the 20 second period is:

A 56 m

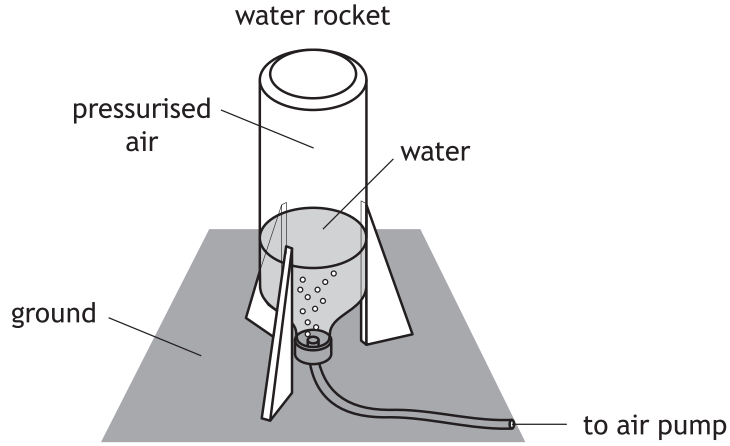
B 144 m

C 160 m

D 176 m

E 200 m.

4. A student is investigating the motion of water rockets.



Air is pumped into the rocket until the pressure of the air inside is large enough for the water rocket to launch upwards.

The rocket launches because:

A the rocket pushes down on the ground and the ground provides a reaction force pushing up on the rocket

B the rocket pushes down on the water and the water provides a reaction force pushing up on the rocket

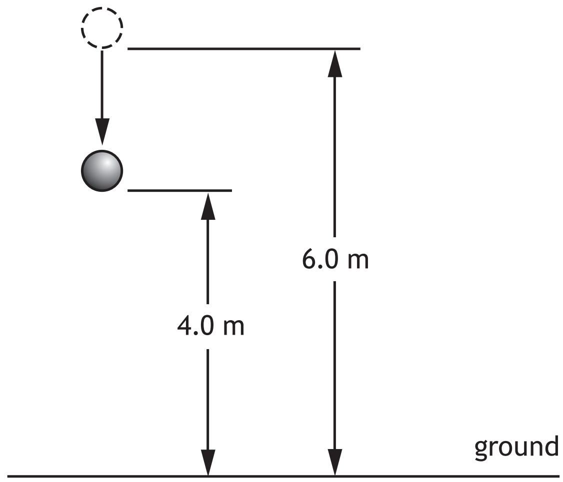
C the water pushes down on the ground and the ground provides a reaction force pushing up on the water

D the force applied by the water on the ground is greater than the weight of the rocket producing an unbalanced upward force

E the weight of the rocket decreases as water is pushed out of the rocket producing an unbalanced upward force.

[Turn over

5. A ball of mass 0.25 kg is released from a height of 6.0 m above the ground.



Which row in the table shows the change in gravitational potential energy and the kinetic energy of the ball when it is at a height of 4.0 m above the ground?

	Change in gravitational potential energy (J)	Kinetic energy (J)
A	14.7	0.0
B	4.9	4.9
C	9.8	4.9
D	4.9	9.8
E	14.7	14.7

6. Astronauts orbiting in the International Space Station experience ‘weightlessness’.

A group of students make the following statements to explain ‘weightlessness’ in the orbiting space station:

I The gravitational field strength inside the space station is zero.

II The space station and astronauts are both accelerating at the same rate towards the Earth.

III The forces acting on the astronauts are balanced.

Which of these statements is/are correct?

A I only

B II only

C III only

D I and II only

E II and III only

7. Which of the following lists the distances from longest to shortest?

A radius of Earth; radius of orbit of Moon; diameter of galaxy

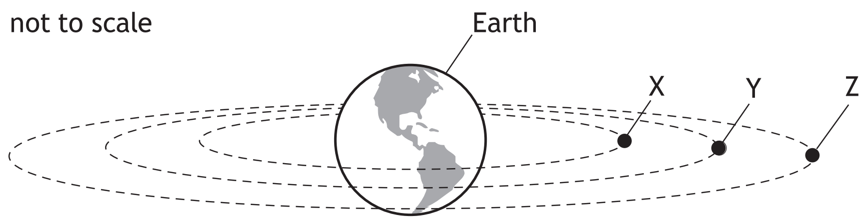
B radius of orbit of Moon; radius of Earth; diameter of galaxy

C diameter of galaxy; radius of orbit of Moon; radius of Earth

D diameter of galaxy; radius of Earth; radius of orbit of Moon

E radius of orbit of Moon; diameter of galaxy; radius of Earth

8. Three satellites X, Y, and Z are orbiting the Earth as shown.



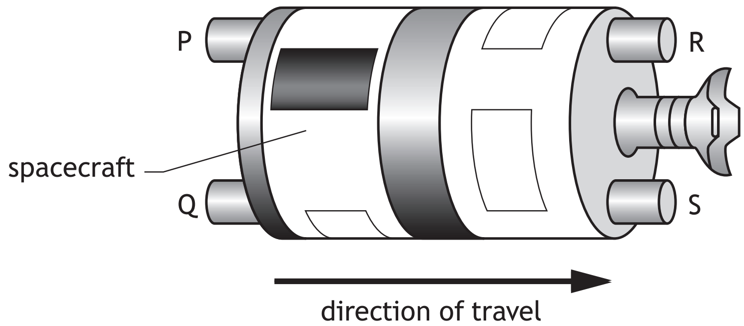
Satellite Z is a geostationary satellite.

Which row in the table shows possible periods for the orbits of satellites X, Y, and Z?

	Period of orbit of satellite X (hours)	**Period of orbit of satellite Y (hours)**	**Period of orbit of satellite Z (hours)**
A	12	18	24
B	24	18	12
C	24	24	24
D	40	36	24
E	4	6	12

[Turn over

9. A spacecraft has four rocket engines P, Q, R, and S and is travelling to the right as shown.



When switched on, each rocket engine produces the same amount of force.

Which rocket engines are switched on to reduce the speed of the spacecraft?

A R and S
B Q and S
C P and Q
D P and R
E P, Q, R, and S

10. The weights of three masses on the surface of a planet are shown in the table.

Mass (kg)	**Weight (N)**
0.50	4.4
2.5	22
4.0	35

The weight of a 6.0 kg mass on the surface of the planet is:

A 0.68 N
B 1.5 N
C 8.8 N
D 53 N
E 59 N.

11. A hair dryer is connected to a 230 V supply. The current in the hair dryer is 2.0 A.

The electrical charge that passes through the hair dryer in 5 minutes is:

A 10 C

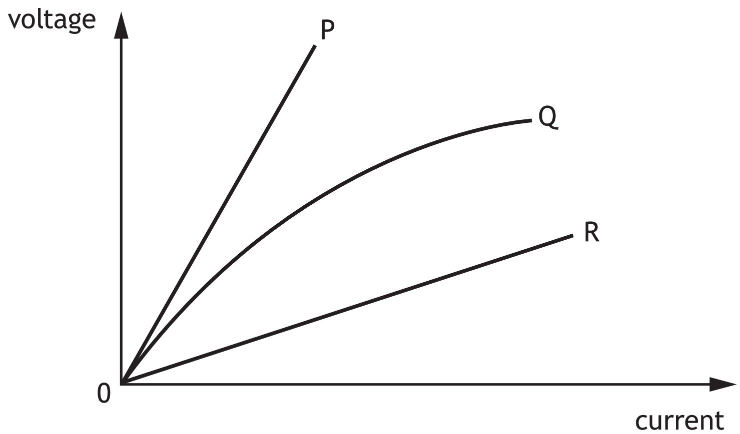
B 460 C

C 600 C

D 1150 C

E 2300 C.

12. The graph shows how the voltages across the components P, Q, and R vary with current.



Based on this graph, a group of students make the following statements:

I Component P has a greater resistance than component R.

II Component R has a greater resistance than component Q.

III Component Q has a resistance that decreases as the current increases.

Which of these statements is/are correct?

A I only

B II only

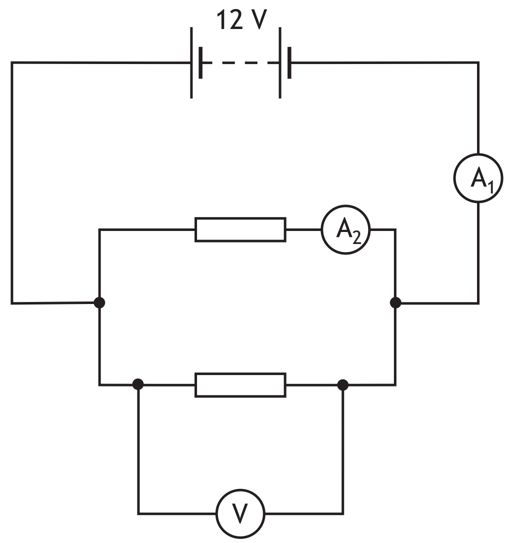
C III only

D I and III only

E II and III only

[Turn over

13. A circuit is set up as shown.

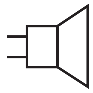


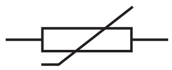
The resistors are identical.

Which row in the table shows the reading on the voltmeter and possible readings on ammeters A_1 and A_2?

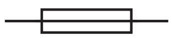
	Reading on voltmeter (V)	Reading on ammeter A_1 (A)	Reading on ammeter A_2 (A)
A	6	0.3	0.3
B	6	0.6	0.3
C	12	0.3	0.3
D	12	0.3	0.6
E	12	0.6	0.3

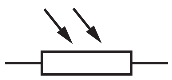
14. Which of the following symbols represents a thermistor?

A 

B 

C 

D 

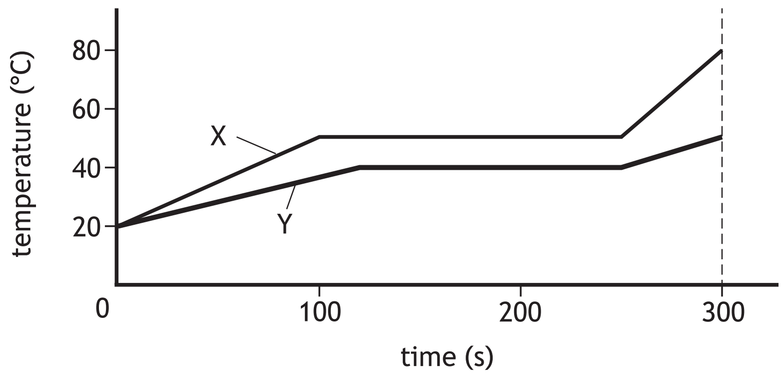
E 

[Turn over

15. Two substances X and Y are both solid at 20 °C.

The substances have the same mass and are supplied with the same amount of energy per second.

The graph shows how the temperature of each substance varies with time.



A student uses information from the graph to make the following statements:

I The specific heat capacity of the solid substance X is greater than that of the solid substance Y.

II Substance X changes state at a higher temperature than substance Y.

III The specific latent heat of fusion of substance X is greater than that of substance Y.

Which of these statements is/are correct?

A I only

B I and II only

C III only

D II and III only

E I, II and III

16. Heat from the Sun melts 1.6 kg of ice in 40 minutes.

The minimum heat energy required to change 1.6 kg of ice at 0 °C into water at 0 °C is:

A 6.7×10^{3} J

B 1.3×10^{4} J

C 2.1×10^{5} J

D 5.3×10^{5} J

E 3.6×10^{6} J.

17. A cyclist is riding a bicycle along a level road.

The combined mass of the cyclist and bicycle is 70.0 kg.

The total contact area between the tyres and the road is 8.0×10^{-4} m^2.

The average pressure exerted by the tyres on the road is:

A 1.2×10^{-6} Pa

B 5.6×10^{-2} Pa

C 8.8×10^{4} Pa

D 4.3×10^{5} Pa

E 8.6×10^{5} Pa.

18. The average kinetic energy of a gas molecule can be determined using the following relationship.

$$E_k = \frac{3}{2} k_B T$$

where: E_k is the average kinetic energy of a gas molecule in joules, J

k_B is Boltzmann's constant $= 1.38 \times 10^{-23}$ J K^{-1}

T is the temperature of a gas molecule in kelvin, K.

The average kinetic energy of a gas molecule at 100 °C is:

A 2.07×10^{-21} J

B 3.58×10^{-21} J

C 5.15×10^{-21} J

D 5.65×10^{-21} J

E 7.72×10^{-21} J.

[Turn over

Back to Table

19. Which of the following is a longitudinal wave?

A sound
B radio
C ultraviolet
D infrared
E light

20. A radio station transmits radio signals with a frequency range from 3.0 MHz to 6.0 MHz.

The maximum wavelength of the radio signal transmitted is:

A 0.01 m
B 0.02 m
C 50 m
D 100 m
E 113 m.

21. A student draws a diagram to show the bands of the electromagnetic spectrum in order of increasing wavelength.

increasing wavelength →

gamma rays	X-rays	infrared	visible light	ultra-violet	micro-waves	radio waves

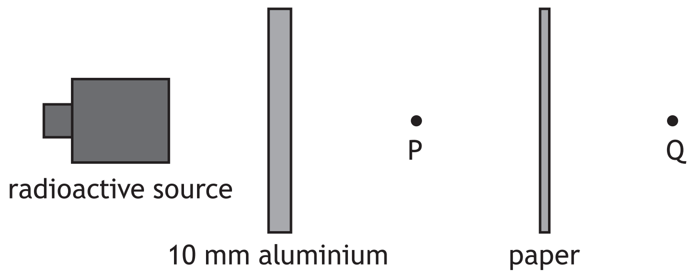
The diagram is **not** correct.

Which **two** bands of the electromagnetic spectrum are in the wrong position?

A gamma rays and radio waves
B X-rays and microwaves
C infrared and ultraviolet
D visible light and microwaves
E X-rays and visible light

22. A radioactive source emits alpha, beta, and gamma radiations.

Sheets of aluminium and paper are placed in front of the source as shown.



Which row in the table shows the radiation(s) from the source detected at points P and Q?

	Radiation(s) detected at P	Radiation(s) detected at Q
A	beta and gamma	gamma
B	beta	alpha
C	beta and gamma	beta and gamma
D	alpha and gamma	gamma
E	gamma	gamma

23. A radioactive sample emits 3000 alpha particles in 2 minutes.

The activity of the sample is:

A 25 Bq

B 1500 Bq

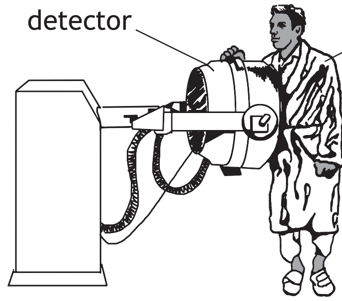
C 3000 Bq

D 6000 Bq

E 360 000 Bq.

[Turn over

24. A radioactive substance is to be injected into a patient so that blood flow can be monitored using a detector.



A number of different substances which emit either beta or gamma radiation are available.

The substances have different half-lives.

Which row in the table identifies the radiation emitted and the half-life of the most suitable substance?

	Radiation emitted	**Half-life**
A	beta	2 days
B	beta	2 years
C	gamma	2 seconds
D	gamma	2 days
E	gamma	2 years

25. Rhodium-106 has a half-life of 30 s.

A sample of rhodium-106 has an activity of 3200 Bq.

The activity of this sample after 120 s is:

A 27 Bq
B 107 Bq
C 200 Bq
D 400 Bq
E 800 Bq.

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET]

Marking instructions for each question

Section 1

Question	Answer	Mark
1.	E	1
2.	C	1
3.	D	1
4.	B	1
5.	B	1
6.	B	1
7.	C	1
8.	A	1
9.	A	1
10.	D	1
11.	C	1
12.	D	1
13.	E	1
14.	B	1
15.	D	1
16.	D	1
17.	E	1
18.	E	1
19.	A	1
20.	D	1
21.	C	1
22.	E	1
23.	A	1
24.	D	1
25.	C	1

FOR OFFICIAL USE

N5

National Qualifications 2022

Mark

X857/75/01

Physics Section 1 — Answer grid and Section 2

FRIDAY, 13 MAY

1:00 PM – 3:30 PM

* X 8 5 7 7 5 0 1 *

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 — 135

SECTION 1 — 25 marks

Attempt ALL questions.

Instructions for 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 X857/75/02 and to the Relationships sheet X857/75/11.

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. 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.

* X 8 5 7 7 5 0 1 0 1 *

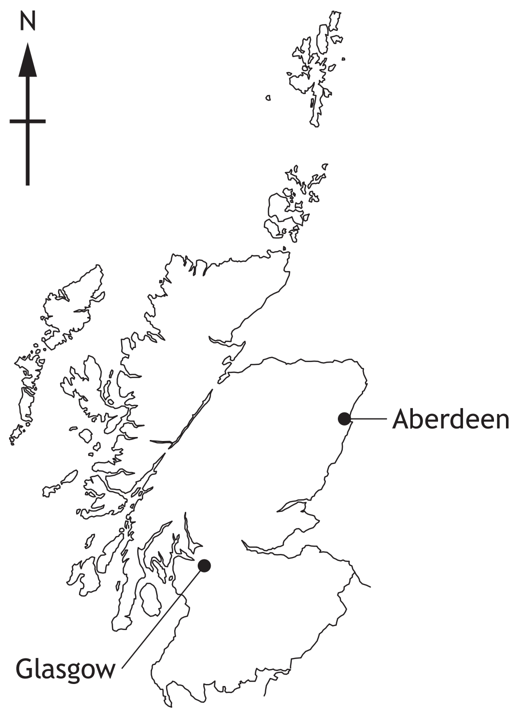
A/PB

SECTION 2 — 110 marks

Attempt ALL questions

MARKS DO NOT WRITE IN THIS MARGIN

1. An aeroplane flies from Aberdeen to Glasgow.



The aeroplane flies 140 km due south (180) from Aberdeen, then 130 km due west (270) to Glasgow.

(a) By scale diagram, or otherwise:

(i) determine the magnitude of the displacement from Aberdeen to Glasgow **2**

Space for working and answer

1. (a) (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(ii) determine the direction of the displacement from Aberdeen to Glasgow. **2**

Space for working and answer

(b) On the return journey, the aeroplane flies **directly** from Glasgow to Aberdeen. The journey takes 0.50 hours.

(i) Calculate the average speed of the aeroplane for this journey. **3**

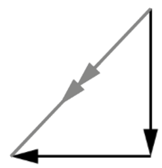
Space for working and answer

(ii) Determine the average velocity of the aeroplane from Glasgow to Aberdeen. **2**

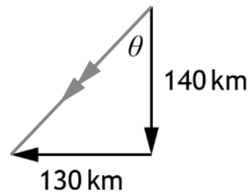
Space for working and answer

[Turn over

Section 2

Question			Expected response	Max mark	Additional guidance
1.	(a)	(i)	**Using scale diagram:**  Vectors to scale **(1)** Resultant = 190 km **(1)** (allow ±5 km) **Using Pythagoras:** $\text{Resultant}^2 = 140^2 + 130^2$ **(1)** Resultant = 190 km **(1)**	**2**	Regardless of method, if a candidate shows a vector diagram (or a representation of a vector diagram eg a triangle with no arrows) and the vectors have been added incorrectly, eg head-to-head then MAX (1). Ignore any direction stated in the final answer in this part. Accept: 200 191 191.0

Back to Table

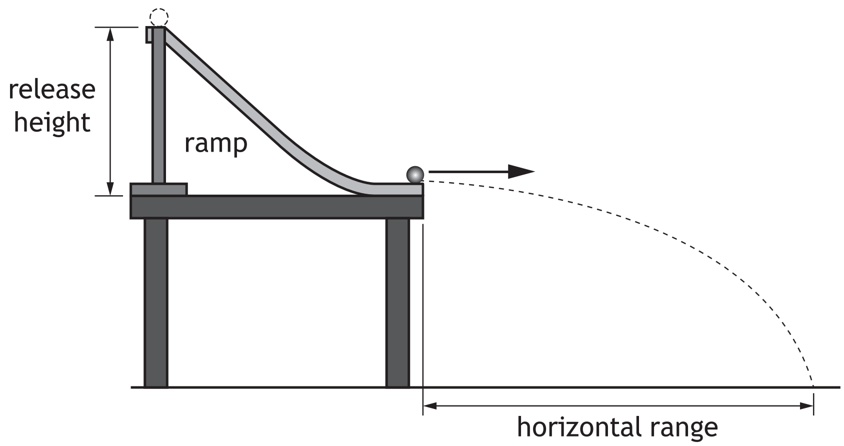
Question			Expected response	Max mark	Additional guidance
1.	(a)	(ii)	**Using scale diagram:**  vectors to scale **(1)** direction = 223 **(1)** (allow ±2° tolerance) **Using trigonometry:** $\tan\theta = \frac{130}{140}$ **(1)** $(\theta = 43°)$ $\text{bearing} = (180 + 43) = 223$ **(1)**	2	Regardless of method, if a candidate (re)draws a vector diagram (or a representation of a vector diagram eg a triangle with no arrows) in this part and the vectors have been added incorrectly, eg head-to-head then MAX (1). **Alternative methods:** $\tan\theta = \frac{140}{130}$ (1) $(\theta = 47°)$ $\text{bearing} = (270 - 47) = 223$ (1) Accept: 47° S of W 43° W of S Ignore the degree symbol if direction is stated as a bearing. Can also do with other trig functions, eg $\sin\theta = \frac{130}{190}$ or $\cos\theta = \frac{140}{190}$ Or use of the magnitude of the resultant consistent with (a)(i) Can obtain first mark for scale diagram method from suitable diagram in part (a)(i) if not drawn in this part. However, the candidate must attempt an answer in this part. Ignore any magnitude stated in the final answer in this part. Accept: 220 222.9 222.88 40° W of S 42.9° W of S 42.88° W of S

Back to Table

Question			Expected response	Max mark	Additional guidance
1.	(b)	(i)	$d = \bar{v}t$ **(1)** $190000 = \bar{v} \times (0.50 \times 60 \times 60)$ **(1)** $\bar{v} = 110\ \text{ms}^{-1}$ **(1)**	**3**	Or consistent with (a)(i) Accept $s = \bar{v}t$ provided it is followed by a substitution of the value for distance. Bar not required above v. Accept: 380 km h^{-1} Accept: 100 106 105.6
		(ii)	110 m s^{-1} **(1)** At 043 **(1)**	**2**	Or magnitude consistent with (b)(i) and/or direction consistent with (a)(ii). Or calculation using displacement consistent with (a)(i) for magnitude Accept: 43° E of N 47° N of E

MARKS DO NOT WRITE IN THIS MARGIN

2. A student is investigating factors that affect the horizontal range of a marble, using the apparatus shown.



(a) The student releases a marble from different heights on the ramp and measures the horizontal range.

The student's results are shown in the table.

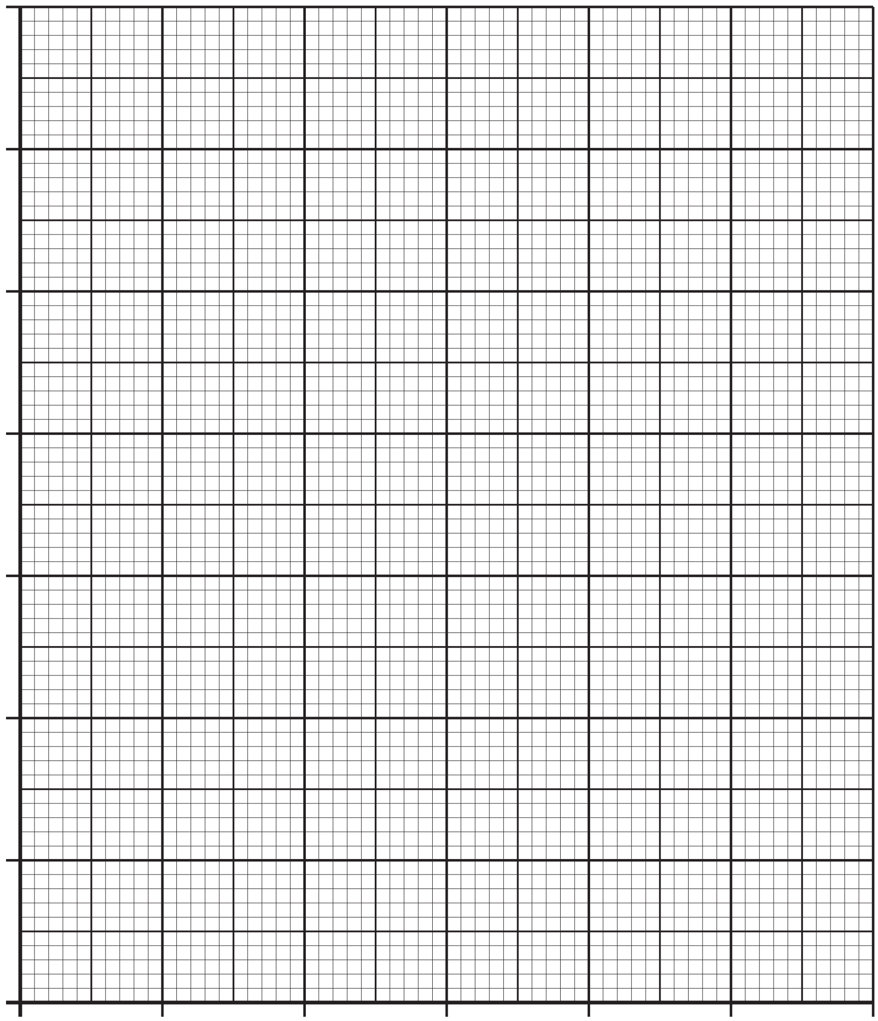
Release height (m)	Horizontal range (m)
0.10	0.39
0.14	0.44
0.18	0.51
0.26	0.64
0.30	0.70

(i) Using the graph paper on *page 09*, draw a graph of these results. **3**

(Additional graph paper, if required, can be found on *page 46*.)

X857750108

2. (a) (i) (continued)



(ii) Use your graph to predict the horizontal range of a marble released from a height of 0.22 m. **1**

2. (a) (continued)

(iii) In order to measure the horizontal range, the student watched to see where the marble hit the ground.

Suggest an improvement to the experiment to determine more accurately where the marble hit the ground. **1**

(b) (i) Suggest another variable that could be investigated, which may affect the horizontal range of a marble. **1**

(ii) Describe experimental work that could be carried out to investigate how the variable you suggested in (b) (i) affects the horizontal range of a marble. **2**

Question			Expected response	Max mark	Additional guidance
2.	(a)	(i)	Suitable scales, labels, and units **(1)** All points plotted accurately to ±half a division **(1)** Best fit straight line **(1)**	**3**	A non-linear scale on either axis prevents access to any marks. (0) Allow broken axes from origin (with or without symbol), but scale must be linear across data range. Axes can be transposed. A bar chart/histogram can obtain MAX (1) for scales, labels, and units.
		(ii)	0.57 m	**1**	**Must** be consistent with the line the candidate has drawn. If the candidate has used a non-linear scale in (a)(i) this mark cannot be accessed. If the candidate has not shown a line in (a)(i) this mark cannot be accessed. ± half a division tolerance Unit must be stated.
		(iii)	Place carbon paper under landing site **OR** Place sand tray under landing site **OR** Use video analysis	**1**	Any sensible answer that could allow the landing point to be clearly identified, within a school/college setting. Do not accept 'place a ruler/grid' alone.
	(b)	(i)	Any suitable variable	**1**	Apply +/- rule for surplus answers. Do not accept: Release height (of marble) Speed/velocity (of marble)
		(ii)	Description of how independent variable will be changed. **(1)** Indication of how a fair test is achieved. **(1)**	**2**	If candidate has stated speed/velocity in (b)(i) then allow a description of how a variable, other than release height, that affects speed/velocity could be investigated.

MARKS DO NOT WRITE IN THIS MARGIN

3. A spaceship on Mars is being prepared for the return journey to Earth.

(a) The mass of the spaceship including fuel and crew is 1.3×10^6 kg.

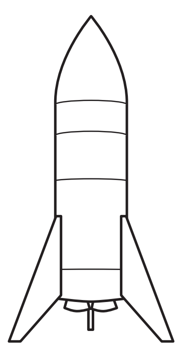
The rocket engines on the spaceship produce a constant upward thrust of 1.2×10^7 N.

(i) Calculate the weight of the spaceship on Mars. **3**

Space for working and answer

(ii) On the diagram below, show all the forces acting vertically on the spaceship just after it leaves the surface.

You must name these forces **and** show their directions. **2**



(An additional diagram, if required, can be found on *page 47*.)

MARKS | DO NOT WRITE IN THIS MARGIN

3. (a) (continued)

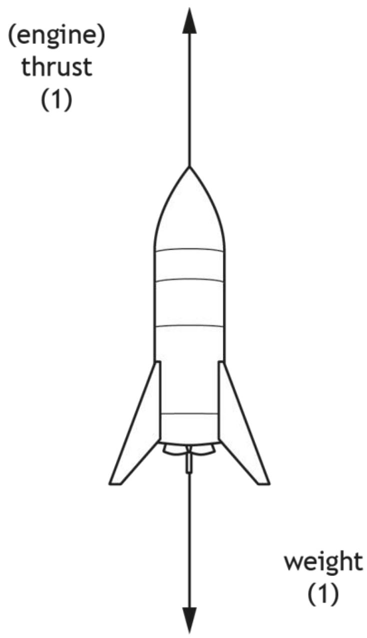
(iii) Determine the acceleration of the spaceship at launch. **4**

Space for working and answer

(b) State what happens to the acceleration of the spaceship as its altitude increases.

Justify your answer. **2**

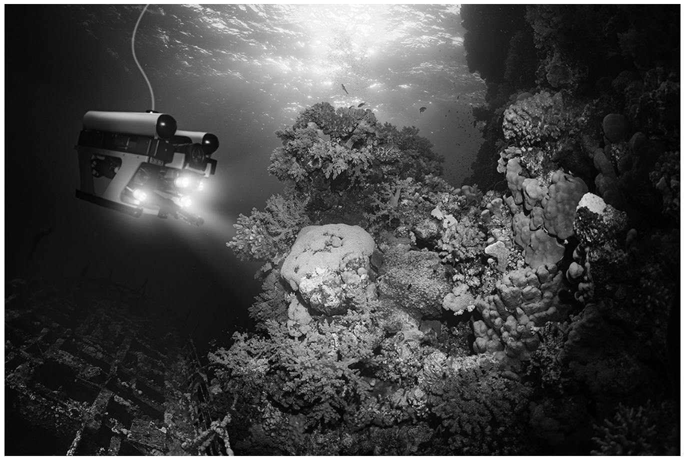
[Turn over

Question			Expected response	Max mark	Additional guidance
3.	(a)	(i)	$W = mg$ (1) $W = 1.3 \times 10^6 \times 3.7$ (1) $W = 4.8 \times 10^6\ \text{N}$ (1)	3	Accept: 5×10^6 4.81×10^6 4.810×10^6
		(ii)		2	(1) for each force correctly labelled with corresponding direction. Accept if arrows do not touch spaceship. Accept: 'rocket thrust' 'force from exhaust gases on rocket' 'force due to gravity' 'gravitational pull' 'pull of gravity' Do not accept: 'upward force' alone 'gravitational field strength' alone 'gravity' alone 'upthrust' Ignore friction/air resistance/drag Ignore horizontal forces Where a candidate has identified more than two vertical forces, apply +/- rule for other vertical forces eg reaction force from ground.
		(iii)	$(F_{un} = \text{engine thrust - weight})$ $F_{un} = 1.2 \times 10^7 - 4.8 \times 10^6$ **(1)** $(F_{un} = 7.2 \times 10^6\ \text{N})$ $F = ma$ **(1)** $7.2 \times 10^6 = 1.3 \times 10^6 \times a$ **(1)** $a = 5.5\ \text{ms}^{-2}$ **(1)**	4	Or consistent with (a)(i) Calculation of unbalanced force may be implied by correct substitution. If no attempt to calculate the unbalanced force, then MAX (1) for the relationship. If clear arithmetic error in calculation of unbalanced force, then MAX (3). Accept: 6 5.54 5.538

Question			Expected response	Max mark	Additional guidance
3.	(b)		Acceleration increases **(1)** Weight/mass decreases (as fuel is used) **OR** Gravitational field strength decreases **(1)**	**2**	Look for this first, otherwise (0) marks Accept: 'Air resistance' reduces (as altitude increases)

MARKS | DO NOT WRITE IN THIS MARGIN

4. Space exploration is often in the news, yet we have only explored about 5% of the oceans on Earth.



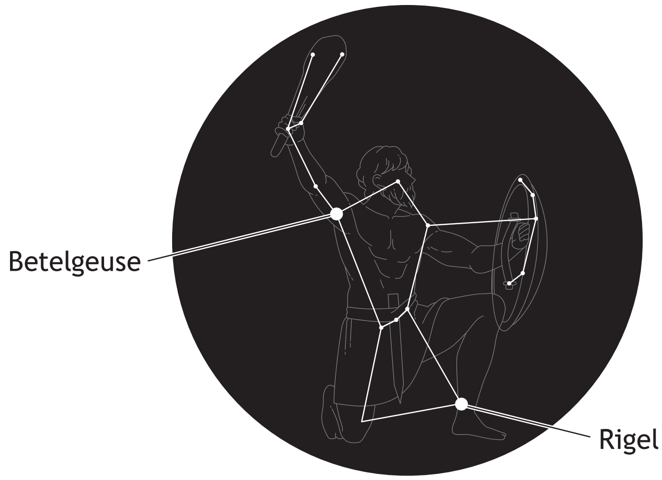
Using your knowledge of physics, comment on the similarities and/or differences between space exploration and underwater exploration. **3**

DO NOT WRITE IN THIS MARGIN

5. Read the passage and answer the questions that follow.

Making plans for Rigel

Betelgeuse might be regularly mentioned in the news but there are other supergiants in the night sky. One of these is Rigel, a blue supergiant star that makes up the 'left foot' of the constellation of Orion. It is approximately 8 million years old and is one of the brightest stars in our night sky.



Orion

Blue supergiants, such as Rigel, are short-lived and are destined to explode as a supernova. Even though Rigel is 860 light-years from Earth, the supernova will be clear to see. Astronomers believe that it will be as bright as a half-moon and will be visible in the sky during the day. However, the light show will only last a few months before it fades.

When it explodes, Rigel will throw debris into space at approximately 5% of the speed of light. Intense waves of radiation, including X-rays and gamma rays, will be radiated into space. The core of the star will collapse into an extremely dense ball of nuclear matter called a neutron star.

It is not possible to predict exactly when Rigel will explode and there is the possibility that it has already happened, it just hasn't been detected yet! The best estimate scientists have is that it will take place within the next million years, or so.

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5. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(a) (i) Calculate the distance, in metres, from Rigel to Earth. **3**

Space for working and answer

(ii) Determine the approximate speed of the debris that will be ejected from the star during the supernova explosion. **1**

Space for working and answer

(iii) Calculate the time it would take for this debris to reach Earth. **3**

Space for working and answer

(b) Explain why the supernova explosion may already have happened but has not yet been detected. **1**

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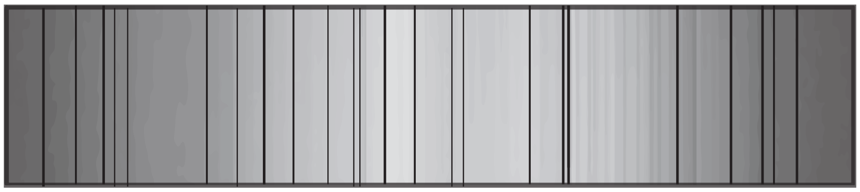
MARKS | DO NOT WRITE IN THIS MARGIN

5. (continued)

(c) Astronomers can identify elements present in stars by studying the spectrum of the light they produce.

A spectrum from a star is shown.



(i) State the type of spectrum shown. **1**

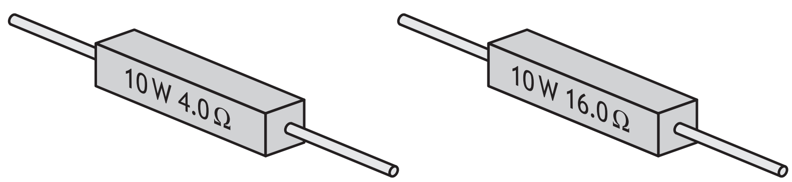
(ii) Explain how the spectrum can be used to identify the elements present in the star. **1**

X857750118

Question			Expected response	Max mark	Additional guidance
5.	(a)	(i)	$d = vt$ **(1)** $d = 3.0\times10^{8} \times(860\times365.25\times24\times60\times60)$ **(1)** $d = 8.1\times10^{18}$ (m) **(1)**	3	This is not a Standard Three Marker. Calculation can be carried out in steps, but all steps must be done for the substitution mark to be awarded, eg calculation of distance for one light-year, followed by multiplying this by 860. Unit in final answer not required, but if stated, must be correct. Accept: 8×10^{18} 8.14×10^{18} 8.142×10^{18} Also accept if using 365 days 8.136×10^{18}
		(ii)	$\left(v = \frac{5}{100}\times3.0\times10^{8}\right)$ $v = 1.5\times10^{7}\ \text{ms}^{-1}$ **(1)**	1	
		(iii)	$d = vt$ **(1)** $8.1\times10^{18} = 1.5\times10^{7}\times t$ **(1)** $t = 5.4\times10^{11}$ s **(1)**	3	Or consistent with (a)(i) and/or (a)(ii) Accept: 5×10^{11} 5.40×10^{11} 5.400×10^{11}
	(b)		Light/EM radiation will take 860 years to reach Earth. **OR** The light/EM radiation from the supernova has not reached Earth yet.	1	Or similar Do not accept explanation in terms of distance alone, rather than time, eg ‘it is 860 light-years away’ Do not award mark if response refers to the time taken for the debris to reach Earth.
	(c)	(i)	line (spectrum)	1	Accept: absorption (spectrum)
		(ii)	(Lines in) this spectrum can be matched/compared with (lines in) the spectrum from the element.	1	Or similar Accept: Each element has a unique spectrum/pattern of lines

6. A ceramic power resistor is a common type of resistor, used in circuits to dissipate large amounts of energy as heat. They are labelled with a power rating and resistance value. MARKS DO NOT WRITE IN THIS MARGIN

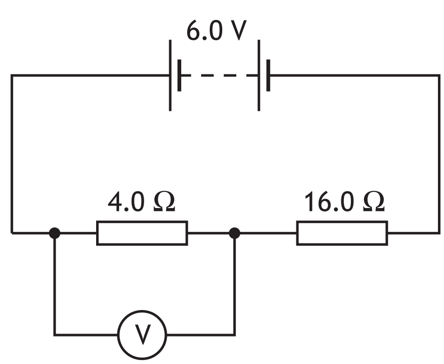
Two examples are shown.



(a) State which of the two resistors will allow the greater current to pass.

You must justify your answer. **2**

(b) The resistors are connected in the circuit shown.



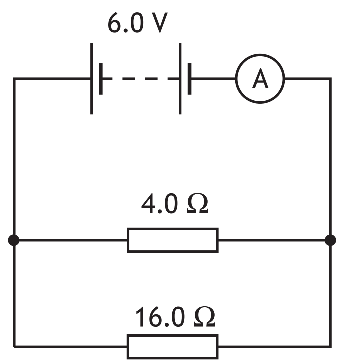
Calculate the reading on the voltmeter. **3**

Space for working and answer

MARKS DO NOT WRITE IN THIS MARGIN

6. (continued)

(c) The two resistors are now connected in another circuit as shown.



(i) Calculate the total resistance of the circuit. **3**

Space for working and answer

(ii) Another ceramic power resistor is now connected in parallel with the two resistors in the circuit.

State the effect this change has on the reading on the ammeter.

Justify your answer. **2**

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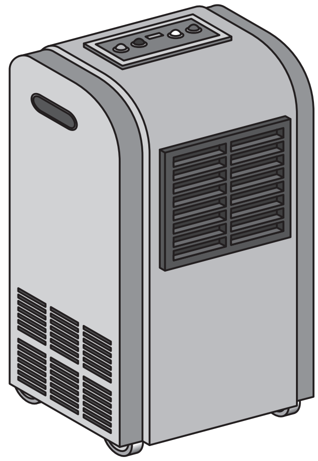
Question			Expected response	Max mark	Additional guidance
6.	(a)		Resistor 1 **(1)** Lower resistance (therefore greater current) **(1)**	**2**	MUST JUSTIFY Resistor correct + justification correct (2) Resistor correct + justification incomplete (1) Resistor correct + justification incorrect (wrong physics) (0) Resistor correct + no justification attempted (0) Incorrect or no resistor stated, regardless of justification (0) Accept justification by appropriate calculation for both resistors.
	(b)		$V_2 = \left(\frac{R_2}{R_1 + R_2}\right) \times V_S$ **(1)** $V_2 = \left(\frac{4.0}{16.0 + 4.0}\right) \times 6.0$ **(1)** $V_2 = 1.2\text{ V}$ **(1)**	**3**	Accept: 1 1.20 1.200 **Method 2:** $V = IR$ $6.0 = I \times 20.0$ $(I = 0.3\text{ A})$ $V = IR$ $V = 0.3 \times 4.0$ $V = 1.2\text{ V}$ (1) for $V=IR$ (even if only seen once) (1) for all substitutions (1) for final answer including unit **Method 3:** $\frac{V_1}{V_2} = \frac{R_1}{R_2}$ (1) $\frac{V_1}{6.0} = \frac{4.0}{(16.0 + 4.0)}$ (1) $V_1 = 1.2\text{ V}$ (1)

Question			Expected response	Max mark	Additional guidance
6.	(c)	(i)	$\frac{1}{R_T}=\frac{1}{R_1}+\frac{1}{R_2}$ **(1)** $\frac{1}{R_T}=\frac{1}{4.0}+\frac{1}{16.0}$ **(1)** $R_T=3.2\ \Omega$ **(1)**	**3**	If wrong equation used eg $R_T=\frac{1}{R_1}+\frac{1}{R_2}$ then (0) marks Accept: 3 3.20 3.200 Accept imprecise working towards a final answer $\frac{1}{R_T}=\frac{1}{R_1}+\frac{1}{R_2}=\frac{1}{4.0}+\frac{1}{16.0}=3.2\Omega$ accept
		(ii)	(Reading on ammeter) increases **(1)** Total resistance decreases **(1)**	**2**	Effect must be correct otherwise (0) marks Accept 'current' in place of 'reading on ammeter' Can be justified by a suitable calculation. It must be clear that it is the resistance of the whole circuit that decreases.

MARKS | DO NOT WRITE IN THIS MARGIN

7. A dehumidifier is an appliance that extracts water from the air around it.



One particular dehumidifier operates at 230 V a.c. and has a power rating of 0.35 kW.

(a) State the fuse rating that should be used for this dehumidifier. **1**

(b) Calculate the resistance of the dehumidifier. **3**

Space for working and answer

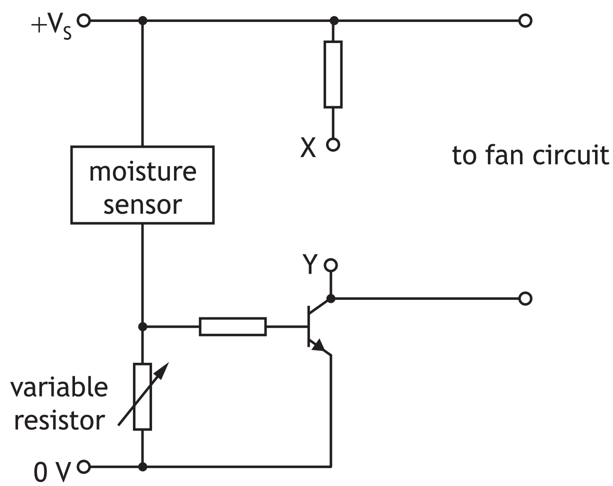
* X 8 5 7 7 5 0 1 2 2 *

MARKS | DO NOT WRITE IN THIS MARGIN

7. (continued)

(c) The dehumidifier switches on automatically when the moisture in the air increases above a certain level. This causes an LED to light and a fan to turn on.

Part of the circuit diagram for the circuit is shown.



(i) Complete the circuit diagram to show the LED connected correctly between X and Y. **1**

(An additional diagram, if required, can be found on *page 48*.)

(ii) The voltage across the moisture sensor decreases as the moisture in the air increases.

Explain how the circuit operates to turn on the LED when the moisture in the air increases above a certain level. **2**

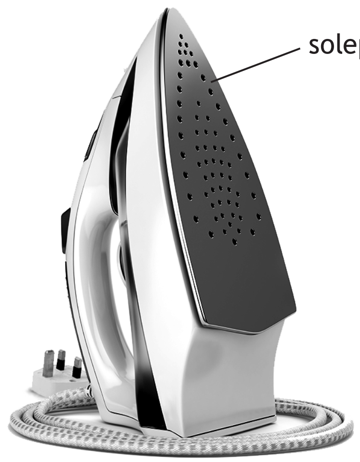
(iii) Explain the purpose of the variable resistor in this circuit. **1**

Question			Expected response	Max mark	Additional guidance
7.	(a)		3 A	**1**	
	(b)		$P=\frac{V^2}{R}$ **(1)** $0.35\times10^3=\frac{230^2}{R}$ **(1)** $R=150\ \Omega$ **(1)**	**3**	Accept: 200 151 151.1 For alternative methods: (1) for all required relationships (1) for all substitutions (1) for final answer including unit
	(c)	(i)	 **OR** 	**1**	Must have correct orientation.
		(ii)	Voltage across variable resistor increases **(1)** Transistor switches on **(1)**	**2**	Do not accept 'voltage through the variable resistor' Ignore any stated values of switching voltage.
		(iii)	To adjust/control the moisture level at which the dehumidifier/transistor LED/fan switches on.	**1**	To adjust/control when the dehumidifier/transistor/LED/fan switches on.

MARKS | DO NOT WRITE IN THIS MARGIN

8. An electric iron operates at 230 V a.c.

The power rating of the iron is 1750 W.



(a) Calculate the current in the iron when it is operating. **3**

Space for working and answer

MARKS DO NOT WRITE IN THIS MARGIN

8. (continued)

(b) When the iron is switched on, it takes 72.0 s for the soleplate to reach the correct temperature.

During this time, 126 000 J of energy is transferred to the soleplate.

(i) The soleplate is made from aluminium.

The mass of the soleplate is 0.650 kg.

The initial temperature of the soleplate is 22 °C.

Determine the maximum temperature reached by the soleplate. **4**

Space for working and answer

(ii) Explain why the maximum temperature reached by the soleplate will be less than that calculated in (b) (i). **1**

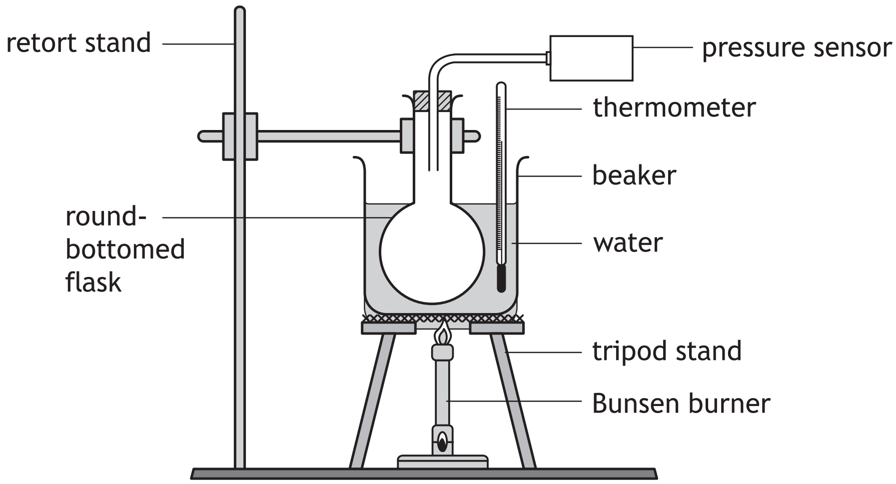
[Turn over

* X 8 5 7 7 5 0 1 2 5 *

Question			Expected response	Max mark	Additional guidance
8.	(a)		$P = IV$ **(1)** $1750 = I \times 230$ **(1)** $I = 7.6$ A **(1)**	**3**	Accept: 8 7.61 7.609
	(b)	(i)	$E_h = cm\Delta T$ **(1)** $126\ 000 = 902 \times 0.650 \times \Delta T$ **(1)** $\Delta T = 215\ (°\text{C})$ **(1)** $(T_{final} = 215 + 22)$ $T_{final} = 237$ °C **(1)**	**4**	If 215 is stated as the final answer it must have the correct unit for the third mark to be awarded. Accept imprecise working towards final answer (eg $\Delta T = 215 + 22 = 237$ °C) accept Accept: 240 236.9 236.91
		(ii)	Heat (energy) is lost to the surroundings/rest of iron/clothes	**1**	Do not accept ‘heat loss’ alone – it must be clear where it is going

9. A group of students are investigating how the pressure of a fixed mass of gas varies with its temperature. This is known as Gay-Lussac's Law.

The students set up an experiment as shown.



The round-bottomed flask contains a fixed mass of gas.

The Bunsen burner is used to heat the apparatus as shown. Readings of temperature and pressure are taken every 10 °C.

During the experiment the volume of the gas in the round-bottomed flask remains constant.

The students' results are shown.

Temperature (°C)	**Temperature (K)**	**Pressure (kPa)**
50	323	121
60	333	124
70	343	128
80	353	132

MARKS DO NOT WRITE IN THIS MARGIN

9. (continued)

(a) Use **all** the appropriate data to establish the relationship between the pressure and the temperature of the gas. **3**

Space for working and answer

(b) Predict the pressure of the gas at a temperature of 100 °C. **1**

(c) Suggest one way the students could improve the experiment. **1**

[Turn over

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MARKS DO NOT WRITE IN THIS MARGIN

9. (continued)

(d) The tyre pressure in racing cars is carefully monitored throughout a race.

As the cars drive around the racing circuit, the temperature of the gas inside the tyres increases.

Explain, using the kinetic model, how this affects the pressure of the gas inside the tyres. **3**

<table>
<tr><th colspan="3">Question</th><th>Expected response</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>9.</td><td>(a)</td><td></td><td>For $\frac{p}{T}$:
$\left(\frac{121\times10^3}{323}\right)=375$
$\left(\frac{124\times10^3}{333}\right)=372$
$\left(\frac{128\times10^3}{343}\right)=373$ (2)
$\left(\frac{132\times10^3}{353}\right)=374$

For $\frac{T}{p}$:
$\left(\frac{323}{121\times10^3}\right)=0.00267$
$\left(\frac{333}{124\times10^3}\right)=0.00269$
$\left(\frac{343}{128\times10^3}\right)=0.00268$
$\left(\frac{353}{132\times10^3}\right)=0.00267$

Statement of relationship:
$\frac{p}{T}=constant$ OR $\frac{T}{p}=constant$
OR $\frac{p_1}{T_1}=\frac{p_2}{T_2}$

OR p is (directly) proportional to T (in kelvin) (1)</td><td>3</td><td>If only 1 or 0 sets of data used (0) for entire question

Calculations:
First two marks are awarded for the calculations:
• All four calculations correct (2)
• Three calculations correct (1)
• Fewer than three calculations correct (0)

Accept 2 - 5 sig figs in all calculated values.

Conversion from kPa to Pa not required

Relationship:
Mark for $\frac{p}{T}=constant$ can only be accessed if the candidate has completed calculations using a minimum of two sets of data, however the relationship must be supported by all the candidate's calculated values.

Do not accept $\frac{pV}{T}=constant$

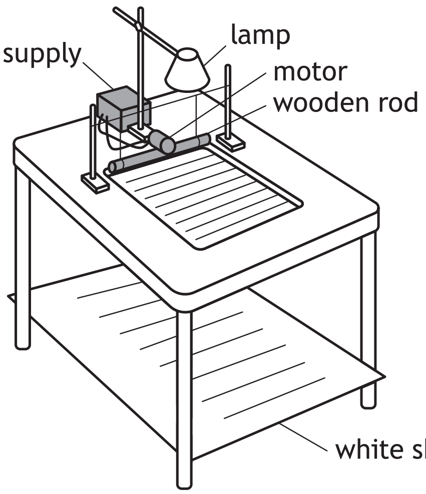
Do not accept: $\frac{p^1}{T^1}=\frac{p^2}{T^2}$</td></tr>
</table>

Question			Expected response	Max mark	Additional guidance
9.	(a)		(continued)		**Alternative method:** If candidate uses $\frac{p_1}{T_1} = \frac{p_2}{T_2}$ to verify values of pressures or temperatures in the table then they must make it clear that the calculated value is approximately the same as the value in the table for any marks to be awarded. Thereafter: All four sets of data linked (minimum of three calculations) (1) All calculations correct (1) Relationship stated and supported (1) **Graphical method:** Must be on graph paper for any marks to be awarded. **(1)** suitable scales, labels and units **(1)** all points plotted accurately to ±half a division and line of best fit **(1)** relationship stated
	(b)		Any single value between 138 kPa and 142 kPa inclusive	**1**	Unit required
	(c)		Repeat the experiment **OR** Increase the range (of temperatures) **OR** Take readings at more (different) temperatures within the range **OR** Have more of the flask in the water **OR** Add more water (in the beaker) **OR** Reduce the length/diameter of the connecting tube **OR** Stir the water	**1**	Accept: Place thermometer inside the flask/in the gas. Apply +/- rule for surplus answers. Candidates do not have to use the terms accurate, precise or reliable, but if they do so they must use them correctly. Accept an appropriate use of insulation (eg 'insulate the connecting tube/top of flask'), but not a generic use of insulation.

Question			Expected response	Max mark	Additional guidance
9.	(d)		(The increase in temperature) increases the kinetic energy of the gas particles/the particles move faster. **(1)** The particles hit the tyre walls more frequently **OR** The particles hit the tyre walls with greater force. **(1)** Pressure (in the tyre) increases **(1)**	**3**	Accept: 'atoms'/'molecules' in place of 'particles' An incorrect statement about collisions does not allow this mark to be awarded eg 'more frequent and less force' or 'less frequent and more force'. Do not accept: 'particles hit the tyre walls more' alone

MARKS | DO NOT WRITE IN THIS MARGIN

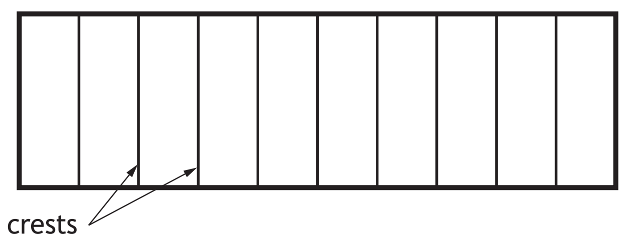
10. A student sets up a ripple tank. A ripple tank is a shallow tank of water used to demonstrate wave properties.



The wooden rod moves in and out of the water to generate water waves.

The pattern of the water waves is projected onto a white sheet of paper below the tank.

The wave pattern appears on the paper as a series of bright and dark lines. The dark lines correspond to the wave crests.



(a) The student determines that there are six complete waves in 0.12 m.

(i) Determine the wavelength of the waves. **1**

Space for working and answer

10. (a) (continued) **MARKS** DO NOT WRITE IN THIS MARGIN

(ii) The six complete waves are produced in a time of 0.40 s.

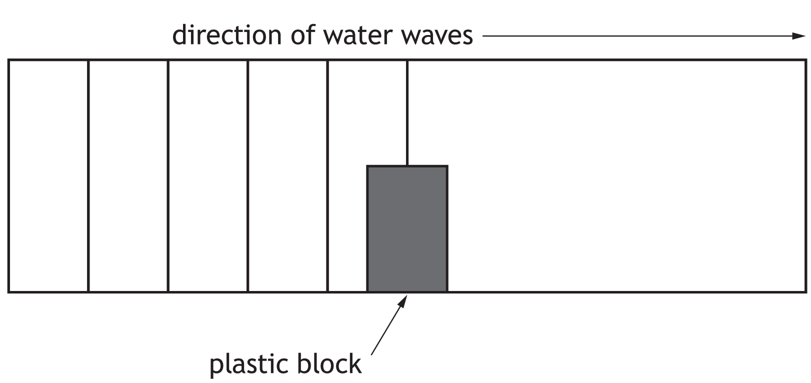
Show that the frequency of the waves is 15 Hz. **2**

Space for working and answer

(iii) Calculate the speed of the waves. **3**

Space for working and answer

(b) The student now places a plastic block in the ripple tank.



Complete the diagram to show the pattern of the water waves beyond the plastic block. **2**

(An additional diagram, if required, can be found on *page 48*.)

Question			Expected response	Max mark	Additional guidance
10.	(a)	(i)	$\left(\lambda = \frac{0.12}{6}\right)$ $\lambda = 0.020$ m **(1)**	1	Unit must be stated Accept: 0.02 0.0200 0.02000
		(ii)	$f = \frac{N}{t}$ **(1)** $f = \frac{6}{0.40}$ **(1)** $f = 15$ Hz	2	**'Show' question** Must state the correct relationship otherwise (0) marks Final answer of 15 Hz, including unit, must be shown, otherwise MAX (1) **Alternative method 1:** $f = \frac{1}{T}$ **(1)** $f = \frac{1}{\left(\frac{0.40}{6}\right)}$ **(1)** $f = 15$ Hz For the second mark to be awarded it must be shown how the period is calculated. **Alternative method 2:** $d = vt$ $0.12 = v \times 0.40$ $(v = 0.30\ \text{ms}^{-1})$ $v = f\lambda$ $0.30 = f \times 0.020$ $f = 15$ Hz (1) for both relationships (1) for all substitutions
		(iii)	$v = f\lambda$ **(1)** $v = 15 \times 0.020$ **(1)** $v = 0.30\ \text{ms}^{-1}$ **(1)**	3	Or consistent with (a)(i) Accept: 0.3 0.300 0.3000 **Alternative method:** $d = vt$ **(1)** $0.12 = v \times 0.40$ **(1)** $v = 0.30\ \text{ms}^{-1}$ **(1)**

Question			Expected response	Max mark	Additional guidance
10.	(b)		diffraction of waves into right 'shadow' region of the plastic block **(1)** consistent wavelengths before and after plastic block **(1)**	**2**	(0) marks if no evidence of diffraction (ie no curved sections), second mark is dependent on first mark. (0) marks if diagram represents diffraction through a gap (ie curved sections at top) Minimum of two waves for any marks to be awarded.

MARKS DO NOT WRITE IN THIS MARGIN

11. A laser produces a narrow beam of concentrated light of one particular wavelength.

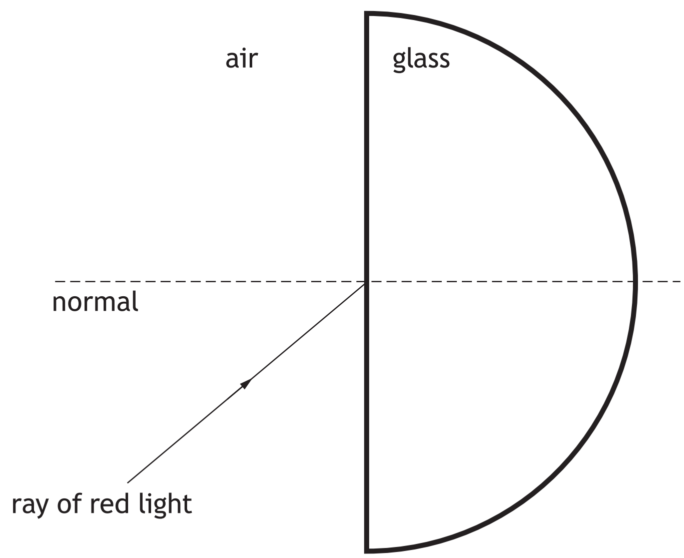
(a) A ray of red light from a laser is directed into a semi-circular glass block.

(i) When the ray of red light enters the block its speed changes.

State the name given to this effect. **1**

(ii) Complete the diagram to show the path of the ray of red light through **and** out of the semi-circular glass block. **1**

(An additional diagram, if required, can be found on *page 49*.)



(iii) State how the wavelength of the red light in the glass compares to the wavelength of the red light in air. **1**

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MARKS DO NOT WRITE IN THIS MARGIN

11. (continued)

(b) The table gives information about the wavelength and output power of various lasers.

Type of laser	Wavelength (nm)	Output power (W)
Argon	514	20
CO_2	10 600	25
Diode	980	10
Nd:YAG	1064	3.0

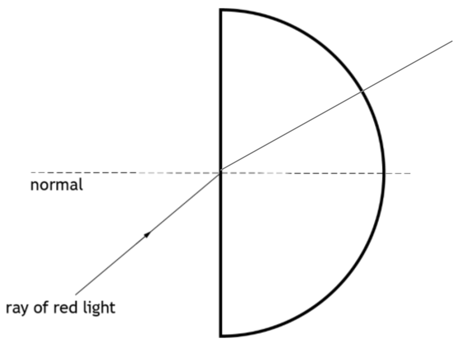
Light from a CO_2 laser is used in dental treatment.

During the dental treatment the CO_2 laser emits short pulses of light.

The average energy per pulse of light is 42.5 mJ.

Calculate the average time for each pulse. **3**

Space for working and answer

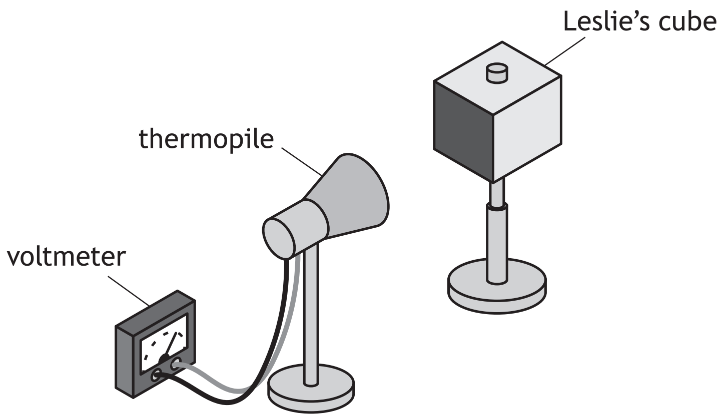
Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	Refraction	**1**	
		(ii)	Correct change in direction on entering block (towards normal) and no change in direction leaving the block **(1)** 	**1**	Arrows not required. Passably straight line. Any change of direction of ray within the block then do not award the mark. Any change of direction of ray after it has left the block then do not award the mark. Do not accept ray in the block drawn along or below the normal.
		(iii)	less	**1**	Accept: 'shorter'
	(b)		$P = \frac{E}{t}$ **(1)** $25 = \frac{42.5 \times 10^{-3}}{t}$ **(1)** $t = 1.7 \times 10^{-3}$ s **(1)**	**3**	Accept: 2×10^{-3} 1.70×10^{-3} 1.700×10^{-3}

12. A student uses a Leslie's cube and thermopile to investigate the amount of infrared radiation emitted by different surfaces of the cube.

A Leslie's cube is a hollow metal cube. Four sides of the cube have different finishes: matt white, matt black, shiny silver, and shiny black.

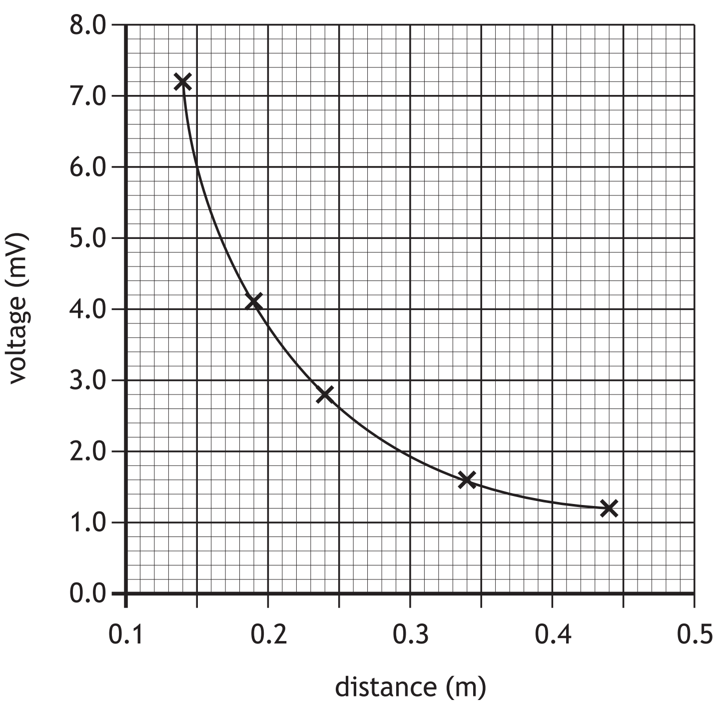
Darker surfaces emit more infrared radiation than lighter surfaces. Matt surfaces emit more infrared radiation than shiny surfaces.

A thermopile is a device that produces a voltage proportional to the amount of infrared radiation detected.



The student fills the cube with hot water and measures the amount of infrared radiation at different distances from the cube, using the thermopile.

(a) The student produces a graph of their results for the matt black side.



MARKS | DO NOT WRITE IN THIS MARGIN

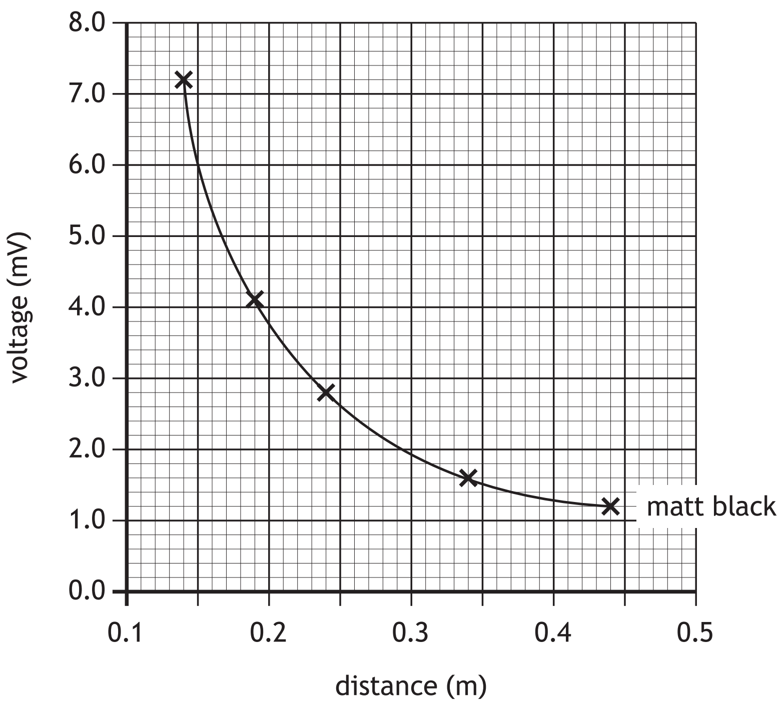
12. (a) (continued)

(i) State a conclusion that can be made about how the distance from a Leslie's cube affects the amount of infrared radiation detected by the thermopile. **1**

(ii) The experiment is repeated using the shiny silver side.

On the graph below, draw a line to show how the voltage produced by the thermopile varies with distance for the shiny silver side. **2**

(An additional graph, if required, can be found on *page 49*.)



[Turn over

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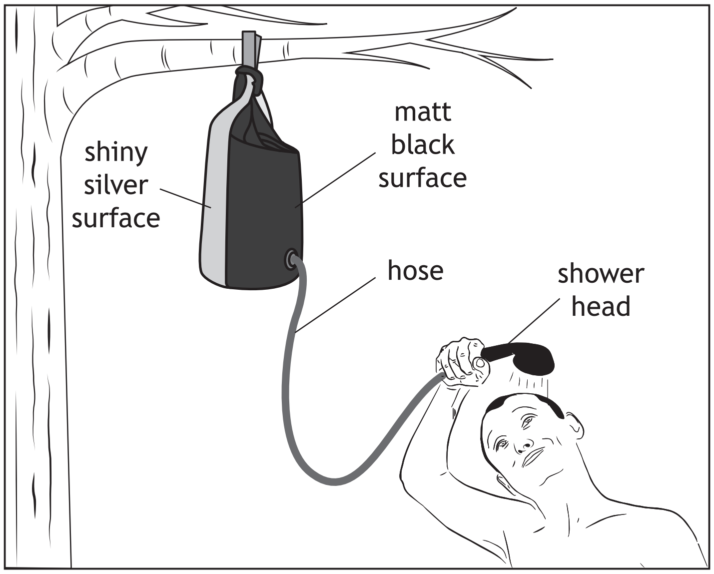
MARKS DO NOT WRITE IN THIS MARGIN

12. (continued)

(b) A solar shower consists of a heavy-duty plastic bag, with a matt black surface and a shiny silver surface, connected to a hose and shower head. The bag uses infrared radiation from the Sun to heat water for a shower, when camping.



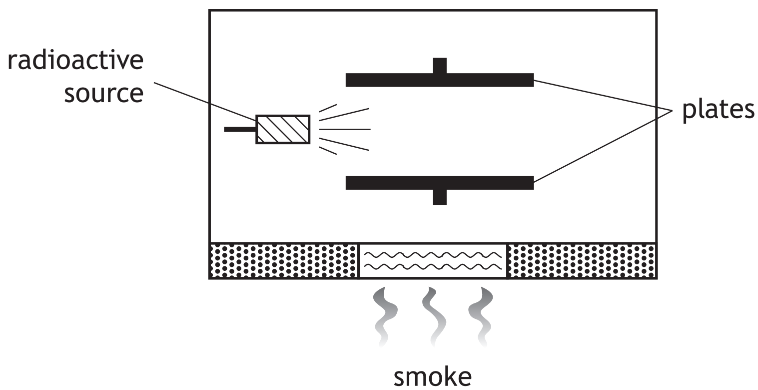
Using your knowledge of physics, comment on how the solar shower works. **3**

Question			Expected response	Max mark	Additional guidance
12.	(a)	(i)	As the distance increases the infrared radiation detected decreases	**1**	Accept: As the distance decreases the infrared radiation detected increases Do not accept: Conclusions that only relate to the relationship between distance and voltage.
		(ii)	Similar shape to original curve **(1)** Line always below original curve **(1)**	**2**	Curve does not need to cover entire range of original curve. Curve can extend beyond the range of the original curve

MARKS | DO NOT WRITE IN THIS MARGIN

13. Smoke detectors are designed to automatically detect smoke and give a warning. It is recommended that smoke detectors are replaced every ten years.

Inside the smoke detector a radioactive source causes ionisation of the air between two electrically charged plates. When smoke enters the detector, the ionisation of the air is reduced.



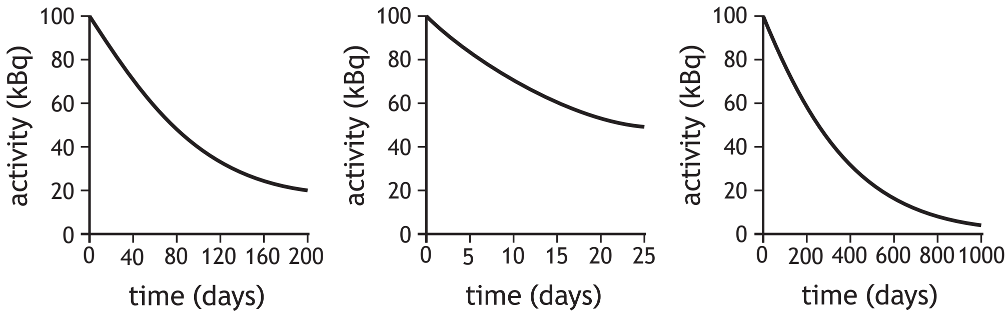
In most smoke detectors the radioactive source used is americium-241, which emits alpha particles.

(a) Give **two** reasons why an alpha radiation source is used rather than a beta or gamma source. **2**

MARKS DO NOT WRITE IN THIS MARGIN

13. (continued)

(b) The graphs show how the activity of three different alpha sources X, Y, and Z change with time.



source X source Y source Z

(i) State which of these three sources has the longest half-life. **1**

(ii) Explain why these sources would **not** be suitable for use in a smoke detector. **2**

[Turn over

* X 8 5 7 7 5 0 1 3 9 *

MARKS DO NOT WRITE IN THIS MARGIN

13. (continued)

(c) Manufacturers must meet health and safety standards for their radiation workers.

During an 8-hour shift, a radiation worker receives an absorbed dose of 4.5 μGy every hour from alpha radiation.

Determine the equivalent dose received by the worker in the 8-hour shift. **4**

Space for working and answer

Question			Expected response	Max mark	Additional guidance
13.	(a)		Alpha is (more easily) absorbed by air/smoke/detector **OR** Alpha has a short(er) range in air **(1)** Alpha is the most ionising **(1)**	**2**	Accept converse statements about why beta <u>and</u> gamma are not suitable. Apply +/- rule for surplus answers
	(b)	(i)	Z	**1**	Accept: Z clearly identified
		(ii)	The <u>half-life</u> of the sources are too short **(1)** The smoke detectors would only work for a short time/need to be replaced frequently/would not last 10 years. **(1)**	**2**	
	(c)		$H = Dw_r$ **(1)** $H = 4.5\times10^{-6}\times20$ **(1)** $(H = 9.0\times10^{-5}\text{ Sv})$ $H = 9.0\times10^{-5}\times8$ **(1)** $H = 7.2\times10^{-4}\text{ Sv}$ **(1)**	**4**	**Alternative method:** $D = 4.5\times10^{-6}\times8$ **(1)** $(D = 3.6\times10^{-5}\text{ Gy})$ $H = Dw_r$ **(1)** $H = 3.6\times10^{-5}\times20$ **(1)** $H = 7.2\times10^{-4}\text{ Sv}$ **(1)** Accept: 7×10^{-4} 7.20×10^{-4} 7.200×10^{-4}

MARKS DO NOT WRITE IN THIS MARGIN

14. Nuclear fission is used in nuclear reactors to generate electricity.

Nuclear fusion happens naturally in stars such as the Sun.

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

(b) Electricity generated from nuclear fission reactions is used to power the engines of an icebreaker ship.

(i) The power output of the nuclear reactor in the icebreaker ship is 150 MW.

Each nuclear fission reaction releases 2.9×10^{-11} J of energy.

Determine the minimum number of fission reactions that occur in the reactor each hour. **4**

Space for working and answer

MARKS DO NOT WRITE IN THIS MARGIN

14. (b) (continued)

(ii) For many years, scientists have been attempting to develop nuclear fusion reactors. Current fusion reactors can only sustain reactions for a limited period of time.

Describe one difficulty in sustaining nuclear fusion reactions in a reactor. **1**

[END OF QUESTION PAPER]

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Question			Expected response	Max mark	Additional guidance
14.	(a)		(Nuclear fission is when a large) nucleus (of an atom) splits (into two or more smaller nuclei).	1	Do not accept: atom alone
	(b)	(i)	$P=\frac{E}{t}$ **(1)** $150\times10^{6}=\frac{E}{60\times60}$ **(1)** $(E=5.4\times10^{11}\text{ J})$ $\text{number of fissions}=\frac{5.4\times10^{11}}{2.9\times10^{-11}}$ **(1)** $=1.9\times10^{22}$ **(1)**	4	Accept: 2×10^{22} 1.86×10^{22} 1.862×10^{22} Calculation of power of one decay over an hour is wrong physics, MAX (1) for relationship. **Alternative method 1:** $P=\frac{E}{t}$ **(1)** $150\times10^{6}=\frac{2.9\times10^{-11}}{t}$ **(1)** $(t=1.93\times10^{-19})$ $\text{number of fissions}=\frac{60\times60}{1.93\times10^{-19}}$ **(1)** $=1.9\times10^{22}$ **(1)** **Alternative method 2:** $\text{fissions per second}=\frac{150\times10^{6}}{2.9\times10^{-11}}$ **(1)** $=5.17\times10^{18}$ **(1)** $\text{total fissions}=5.17\times10^{18}\times60\times60$ **(1)** $=1.9\times10^{22}$ **(1)**
		(ii)	Any one of: Requires high temperatures Difficult to control/contain plasma Requires strong magnetic fields	1	Or any other suitable statements relating to difficulties in sustaining reactions. Accept: 'Requires high pressure' 'Difficult to control/contain energy/heat produced' Answers in terms of cost alone are insufficient. Apply +/- rule for surplus answers.

[END OF MARKING INSTRUCTIONS]