National 5 Past Papers

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 MC	2014	2015 MC	2015	2016 MC	2016	2017 MC	2017	2017 SP MC	2017 SP	2018 MC	2018
Vectors and Scalars	14,15	11c	14	7	14	9	14	8a,c	1,2	b	1,2	1a(i),2
v-t graphs and Acceleration		10	15	8	15	10a,b	15,16	8b		1a,c		2a(iii), b,c
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
Energy	4,16		16	11a	16		1		5,6	2c(ii)	4	3a,b
Projectile motion	19			9	18			11a,b				3c
Space exploration and Cosmology	18		19,20		20	13c,d	18,20	12	7,8	2,3	5,6,7, 8,9,10	4
Electrical Charge Carriers					2	1	2	1b	9,10		11,12	6c
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
Electrical Power & Energy		1a	4	2		3b		1a,2, 11c		5b	4,15	8b
Specific heat Capacity & Specific latent heat	20	3			19	3a	5,19		13,15	7	16	8a,c
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
Wave parameters & behaviours	8	4a	7	3	8,9, 10		8 ,9,10	4	18,19	9	20	10,11b
Electromagnetic spectrum	9		8			4	11	b(i)	20		21	11a
Refraction of light		4b		5a-c	11	6	12		21			11c
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
Open ended		7,9		4 , 10		5, 11		5,10		4,10		5,7
Unseen formula		5								2d	22	
Experimental Methods				11b,c								

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	$3\cdot0 \times 10^8$
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

SECTION 1

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

A resistance of the circuit

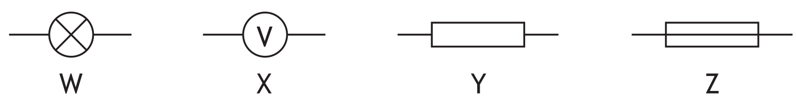
B speed of the charges in the circuit

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?

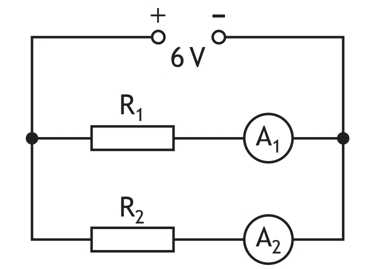
	W	*X*	*Y*	*Z*
A	battery	ammeter	resistor	variable resistor
B	battery	ammeter	fuse	resistor
C	lamp	ammeter	variable resistor	resistor
D	lamp	voltmeter	resistor	fuse
E	lamp	voltmeter	variable resistor	fuse

[Turn over

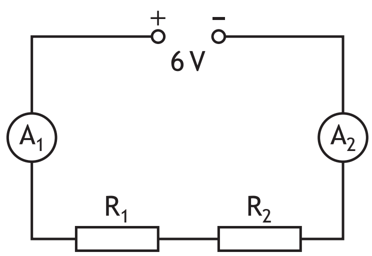
3. A student suspects that ammeter A_1 may be inaccurate. Ammeter A_2 is known to be accurate.

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

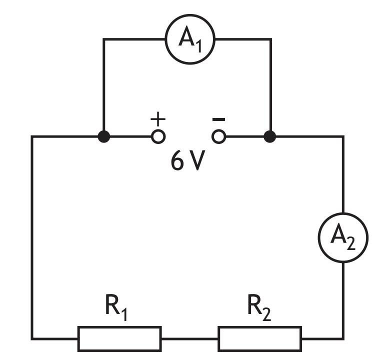
A



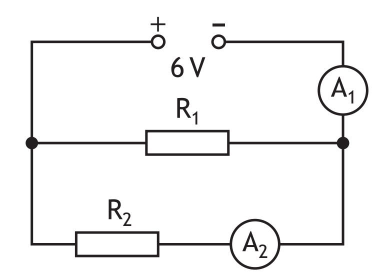
B



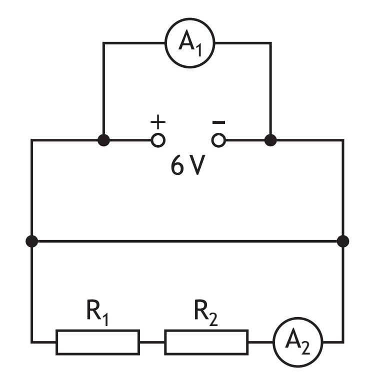
C



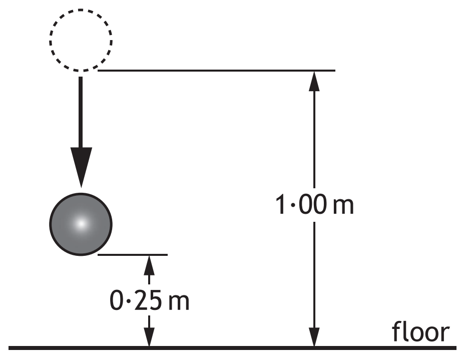
D



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

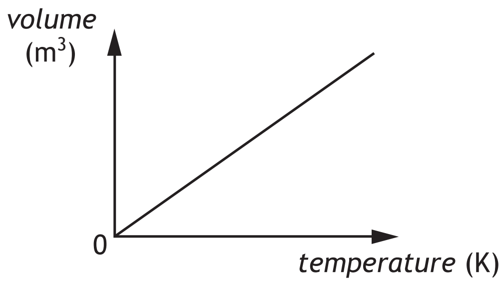
E $1{\cdot}3 \times 10^6$ Pa

[Turn over

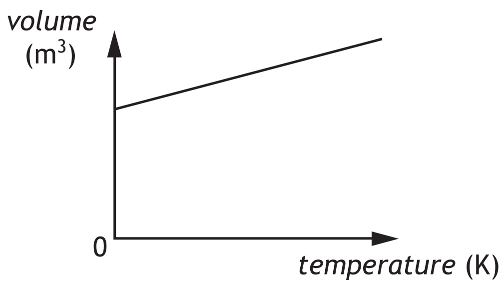
6. A student is investigating the relationship between the volume and the kelvin temperature of a fixed mass of gas at constant pressure.

Which graph shows this relationship?

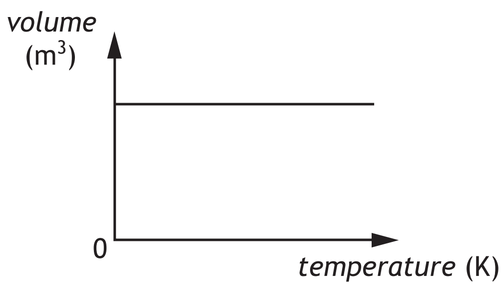
A



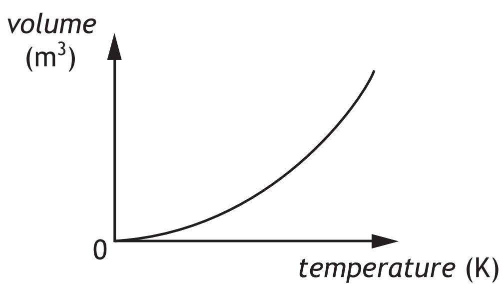
B



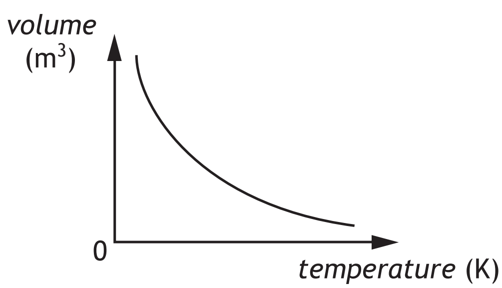
C



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

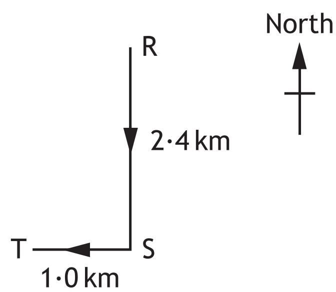
B Displacement, force, velocity

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

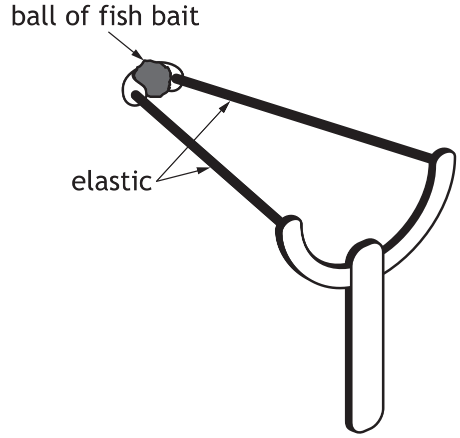
D 30 J

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

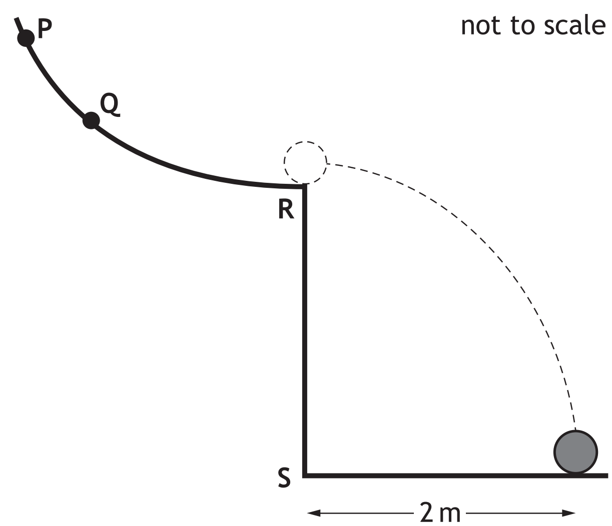
C the air resistance is greater than the weight of the spacecraft

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**.



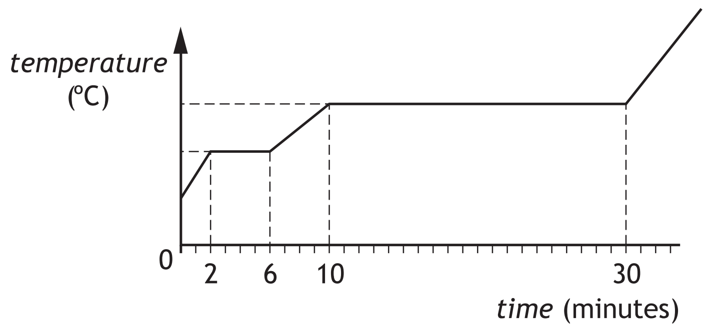
Which row describes the motion of the ball after leaving the rail?

	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**

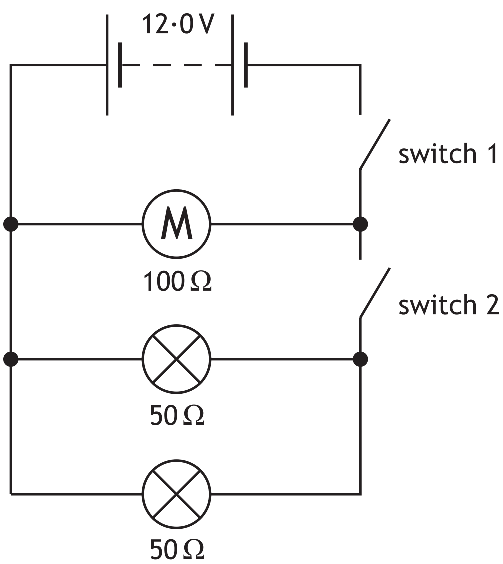
SECTION 2 — 90 marks

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

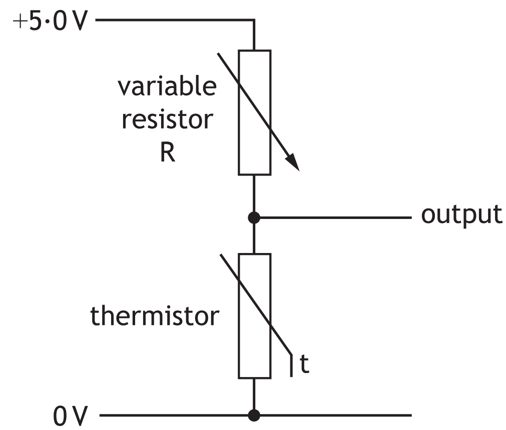
Question			Answer	Max Mark	Additional Guidance
1.	(a)		$P=\frac{V^2}{R}$ (1) $=\frac{12\cdot0^2}{100}$ (1) $=1\cdot44$ W (1)	**3**	Accept 1, 1·4, 1·44 Do not accept: 1·40 Alternative methods: $I=\frac{V}{R}$ $=\frac{12\cdot0}{100}$ $=0\cdot12$ (A) $P=IV$ $=0\cdot12\times12$ $=1\cdot44$ W OR $P=I^2R$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

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.

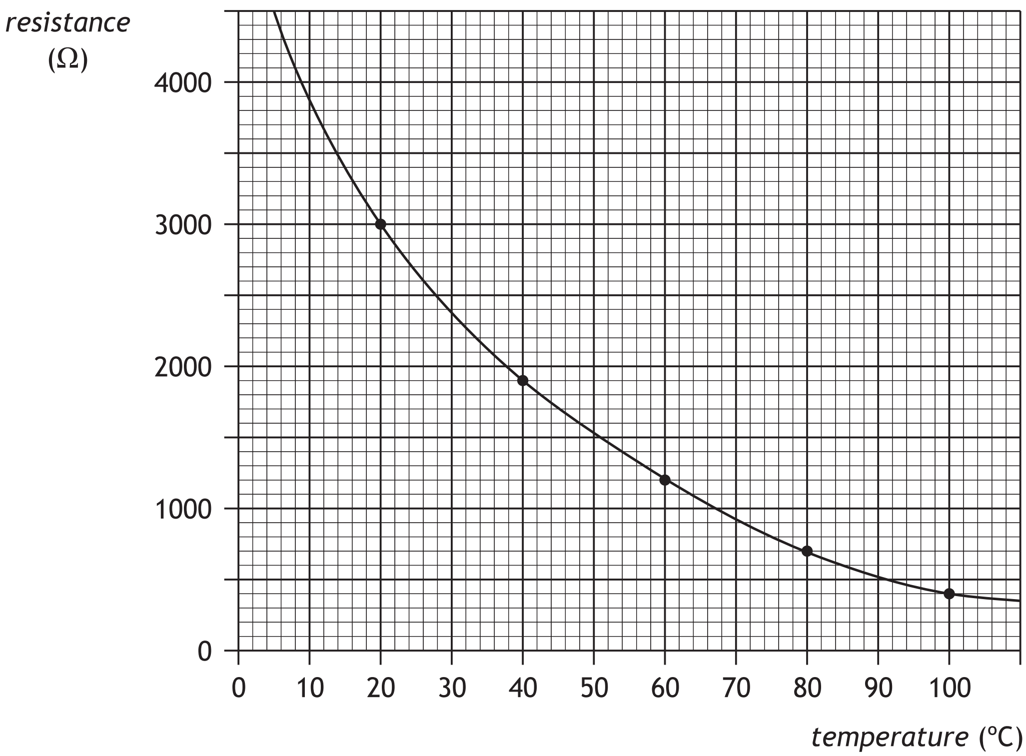
Calculate the resistance of the thermistor when the voltage across the thermistor is 2·0 V. **4**

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.

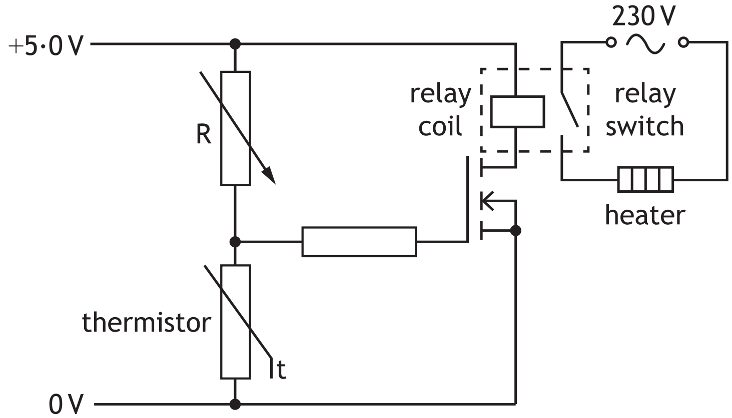


Use the graph to determine the temperature of the water when the voltage across the thermistor is 2·0 V. **1**

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) $I = \dfrac{V_2}{R}$ $= \dfrac{3{\cdot}0}{1050}$ $= (2{\cdot}857 \times 10^{-3}$ A) $R_1 = \dfrac{V_1}{I}$ $= \dfrac{2{\cdot}0}{2{\cdot}857 \times 10^{-3}}$ $= 700\ \Omega$	**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 $V_2 = \left(\dfrac{R_{th}}{R_V + R_{th}}\right) \times V_S$ (1) $2{\cdot}0 = \left(\dfrac{R_{th}}{1050 + R_{th}}\right) \times 5{\cdot}0$ (2) $R_{th} = 700\ \Omega$ (1)

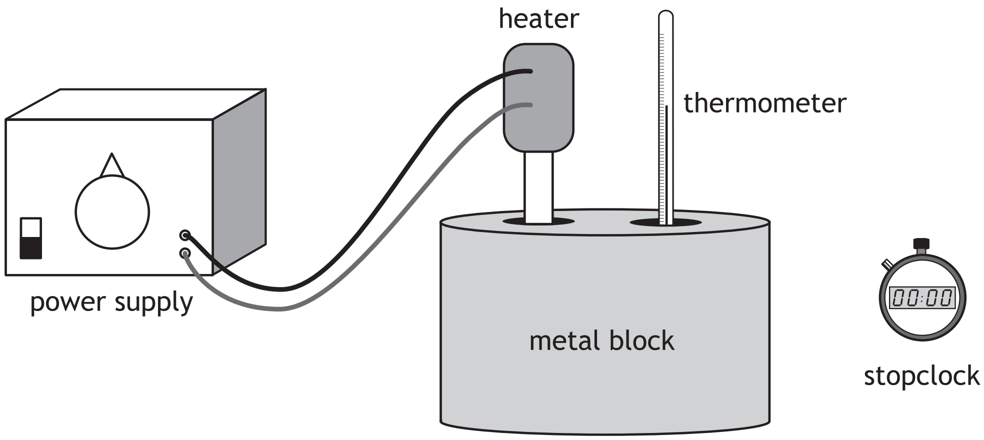
Question			Answer	Max Mark	Additional Guidance
		(ii)	80 °C	**1**	Or answer consistent with 2(a)(i) Unit required +/- half box tolerance
	(b)	(i)	(As R_{th} increases,) V_{th} increases (1) (When V_{th} = 2·0 V or V reaches switching voltage,) MOSFET/transistor turns **on** (1) Relay switches **on** (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**

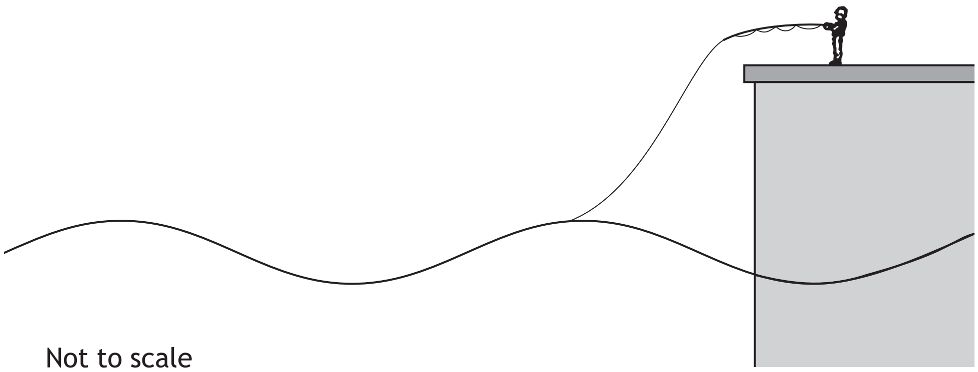
(ii) State the effect that this improvement would have on the final temperature. **1**

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

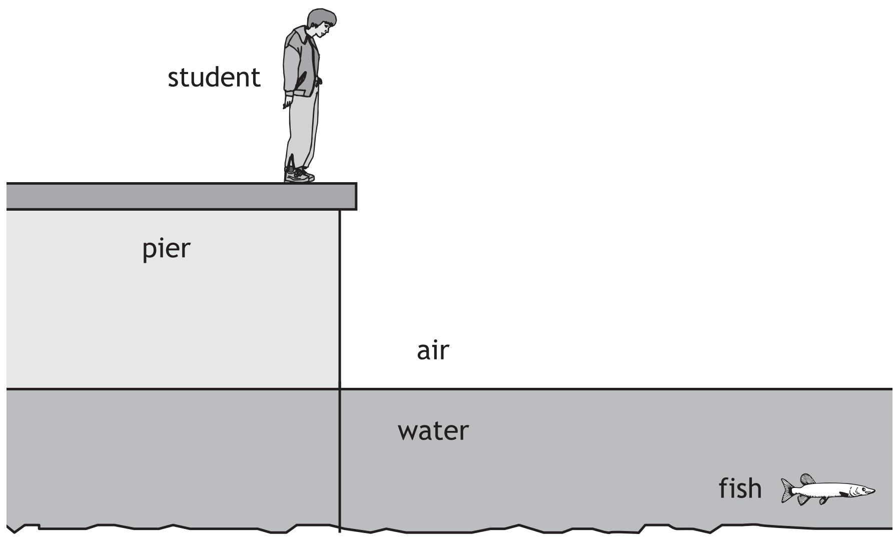
(a) Calculate the speed of the water waves. **4**

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.

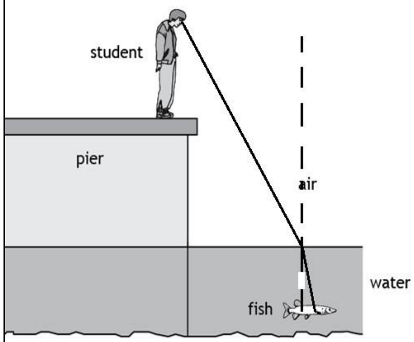
You should include the normal in your diagram. **3**

(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

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

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.

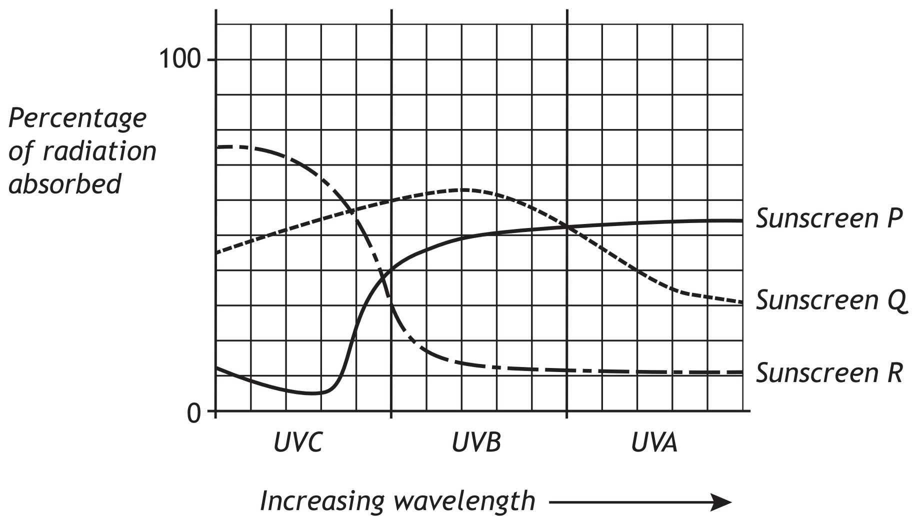
The elevation is 2 km above sea level with overcast skies.

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

Back to Table

[Turn over

<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

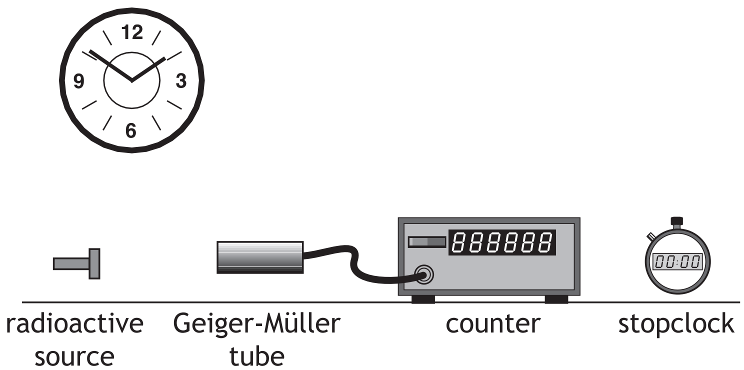
UV index = (280 x 1·12 x 0·31) ÷ 25 (1)

= 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><th></th><th>UVA</th><th>UVB</th><th>UVC</th></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>

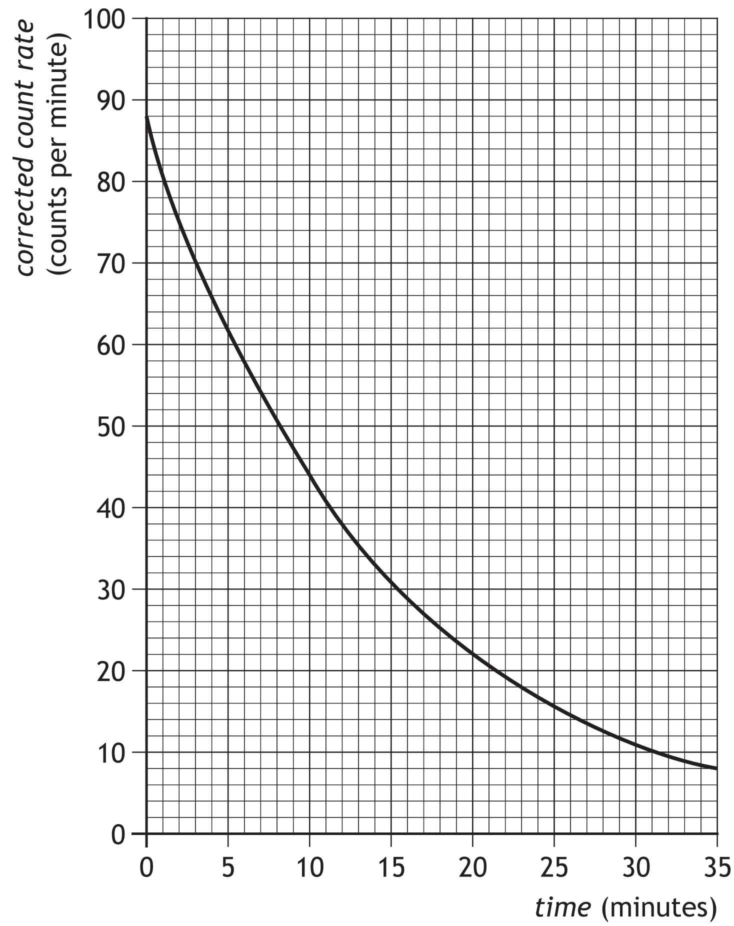
MARKS | DO NOT WRITE IN THIS MARGIN

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.



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

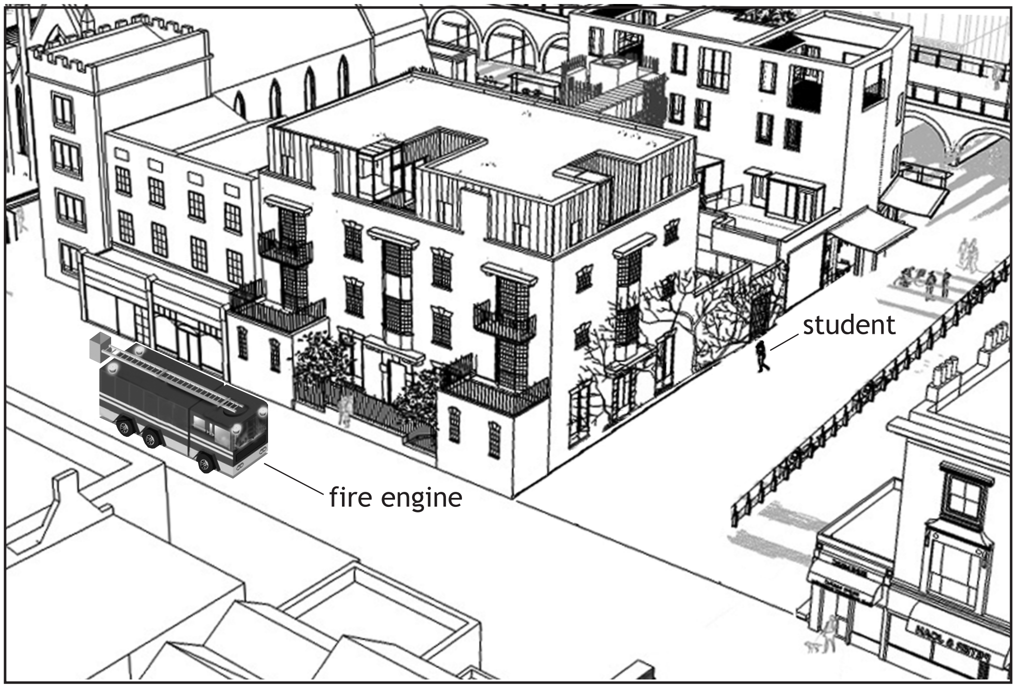
Total marks 7

			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

MARKS DO NOT WRITE IN THIS MARGIN

8. (continued)

(b) X-rays can cause ionisation.

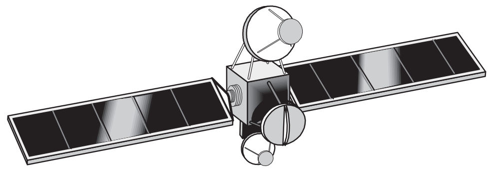
Explain what is meant by *ionisation*. **1**

Total marks 7

Question			Answer	Max Mark	Additional Guidance
8.	(a)	(i)	$D = \frac{E}{m}$ (1) $= \frac{7 \cdot 2 \times 10^{-3}}{80 \cdot 0}$ (1) $= 9 \cdot 0 \times 10^{-5}$ Gy (1)	**3**	
		(ii)	$H = Dw_R$ (1) $= 9 \cdot 0 \times 10^{-5} \times 1$ (1) $= 9 \cdot 0 \times 10^{-5}$ 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.



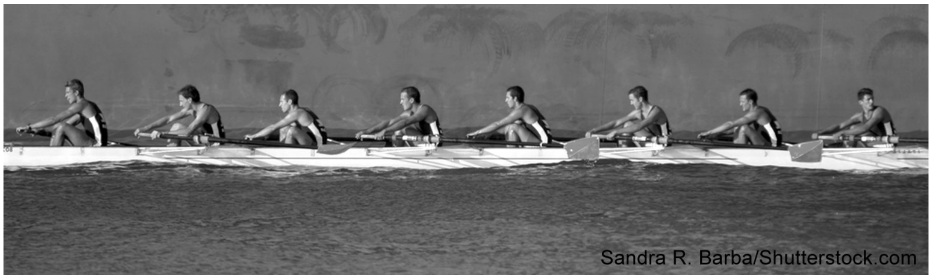
A student states that, to allow the live television broadcasts to be received in Canada, it is important that the satellite does not move.

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

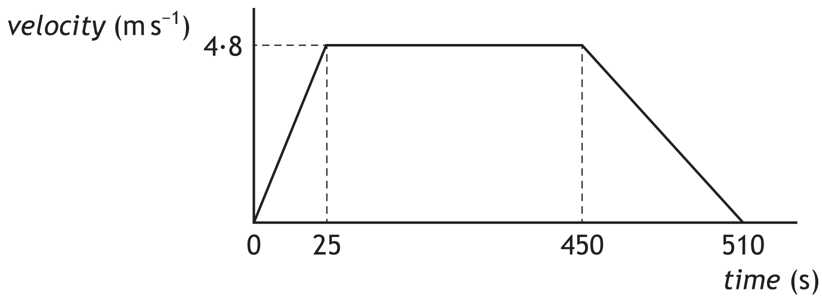
[Turn over

MARKS DO NOT WRITE IN THIS MARGIN

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**

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**

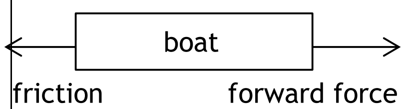
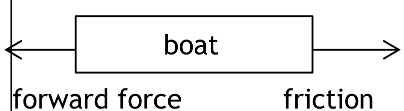
Space for working and answer

(ii) Calculate the average velocity of the boat.

A direction is not required. **3**

Space for working and answer

Total marks 12

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)	 OR 	**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.

Back to Table

Question			Answer	Max Mark	Additional Guidance
	(b)	(i)	distance = area under graph (1) $=\left(\frac{1}{2}\times25\times4\cdot8\right)+\left(4\cdot8\times425\right)$ $+\left(\frac{1}{2}\times60\times4\cdot8\right)$ (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)

Back to Table

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

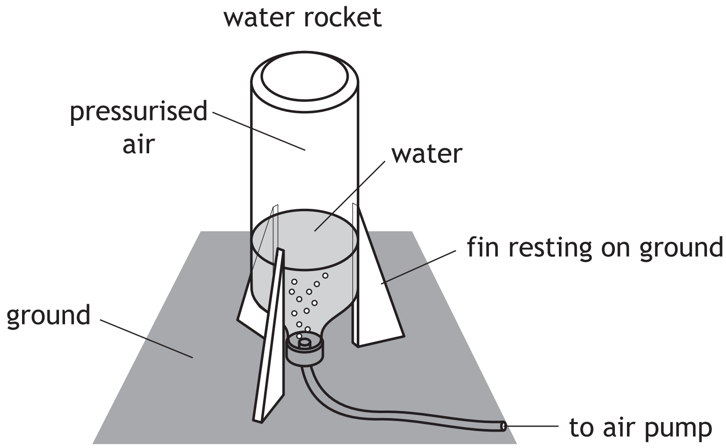
Total marks 5

[Turn over

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** $A = 3 \times (2 \cdot 0 \times 10^{-4})$ $= 6 \cdot 0 \times 10^{-4}$ (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

Back to Table

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) $= 380$ 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.

X757502

HTP

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

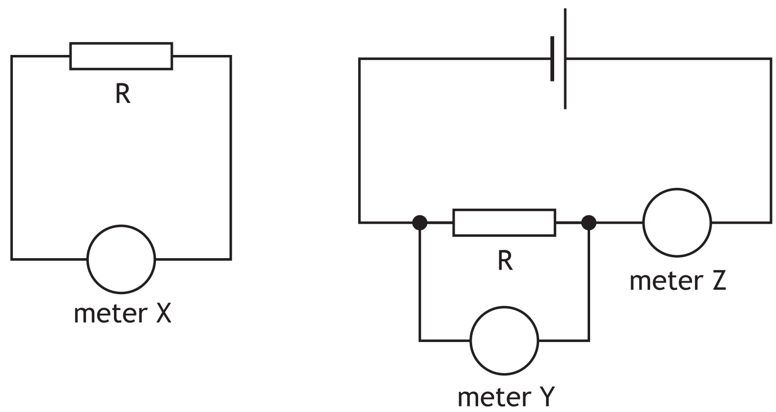
Radiation weighting factors

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

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

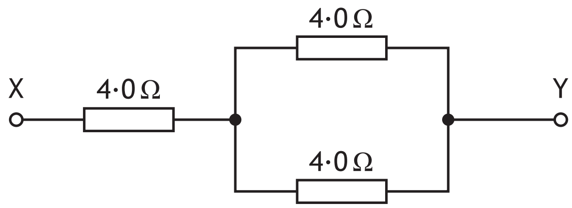
C III only

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

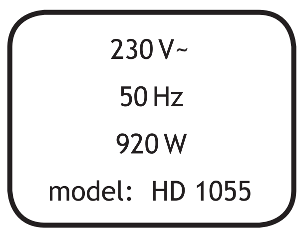
B 4·5 Ω

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

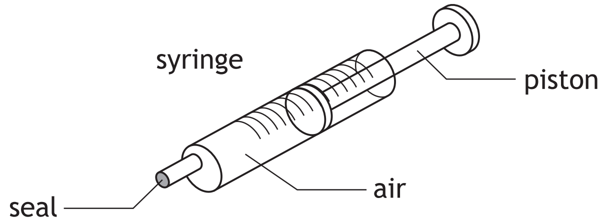
B 0·25 Ω

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

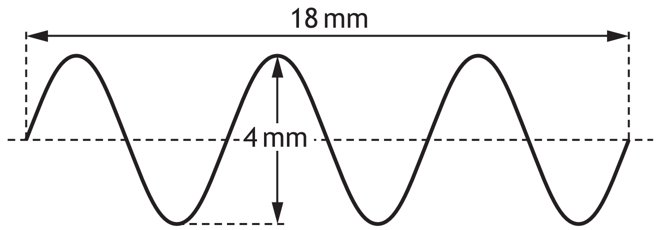
C 150 kPa

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

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

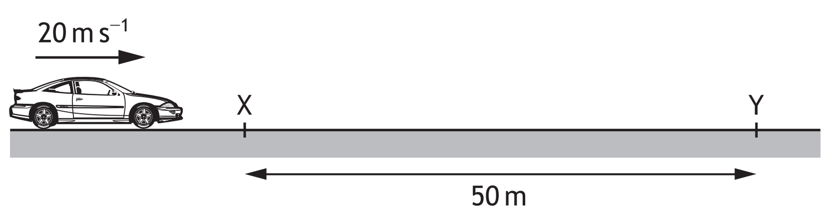
C I and II only

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

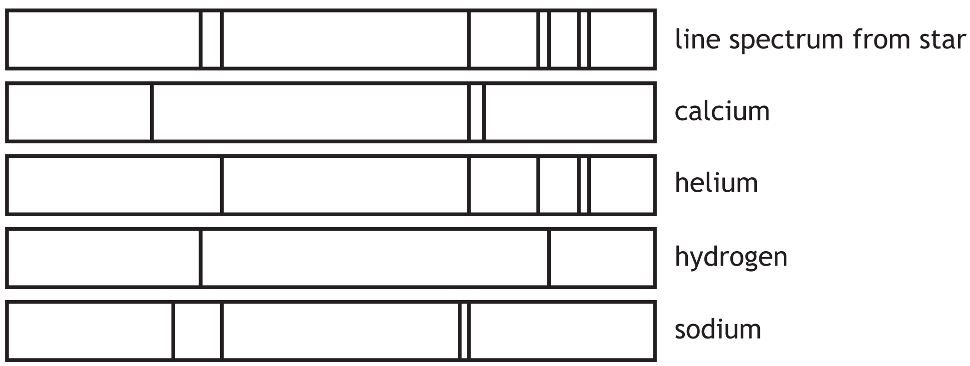
B $1{\cdot}6 \times 10^{14}$ m

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

Back to Table

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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

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.

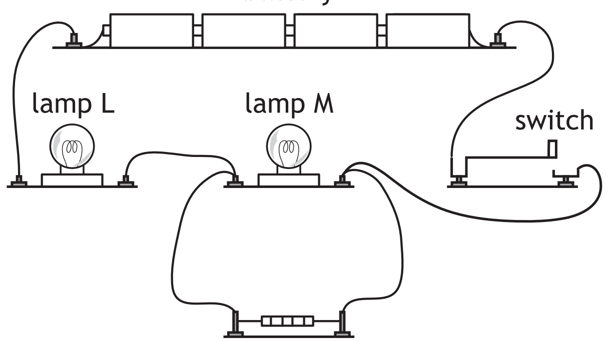
Back to Table

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

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

MARKS DO NOT WRITE IN THIS MARGIN

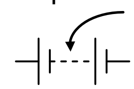
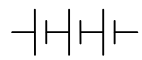
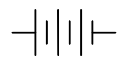
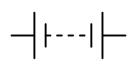
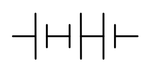
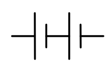
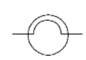
1. (continued)

(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

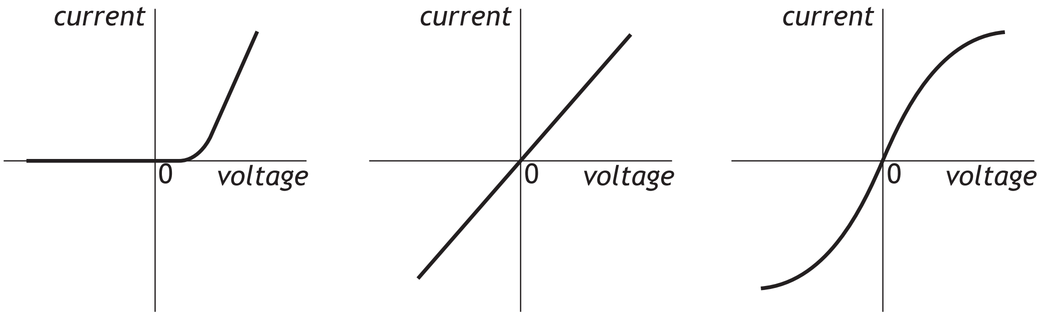
Question			Answer	Max Mark	Additional Guidance
1.	(a)		2 marks for symbols: • All correct (2) • At least two different symbols correct (1) 1 mark for correct representation of external circuit wiring with no gaps	**3**	Must be three or more cells with consistent polarity or a battery symbol. i.e. Accept: 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 parallel (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 parallel (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' Lamp M is dimmer' Accept converse justifications eg 'current in lamp M is less than lamp L'

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

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

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

X757750109

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**	

Back to Table

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.

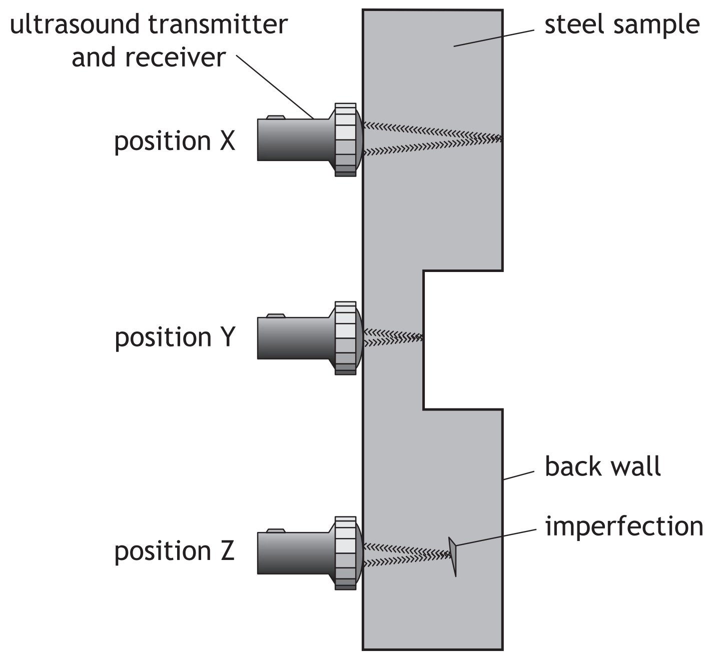
The speed of ultrasound in steel is $5200\,m\,s^{-1}$.

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

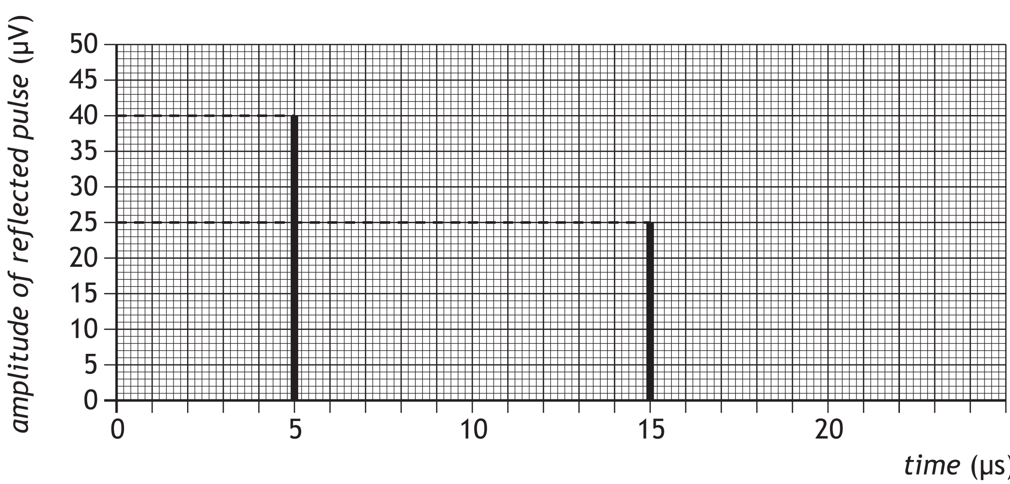
Where there are imperfections in the steel, the pulses of ultrasound are reflected by these imperfections.

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.



X757750110

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

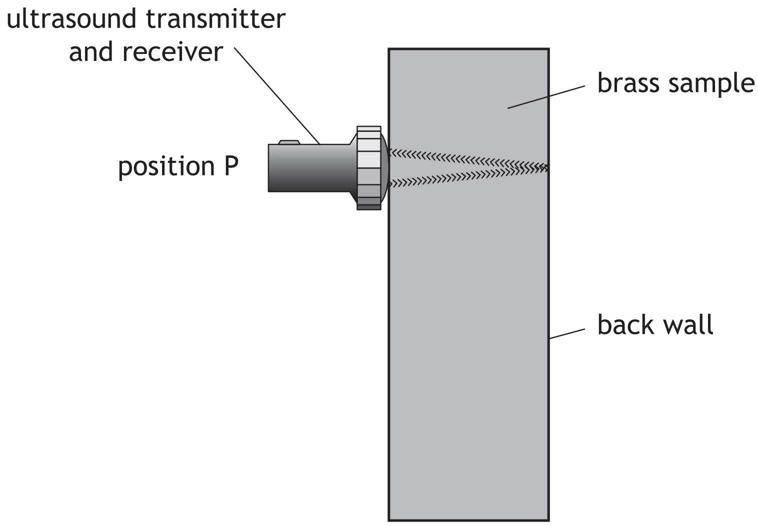
MARKS | DO NOT WRITE IN THIS MARGIN

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.

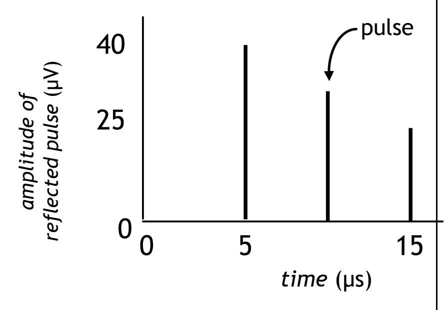


The time between the ultrasound pulse being transmitted and received at position P is greater than the time recorded at position X in the steel sample.

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**

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

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) $thickness = \dfrac{0\cdot078}{2}$ $= 0\cdot039\ \text{m}$ (1) **Method 2:** $time = \dfrac{15\times10^{-6}}{2}$ $= 7\cdot5\times10^{-6}\ (\text{s})$ (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**

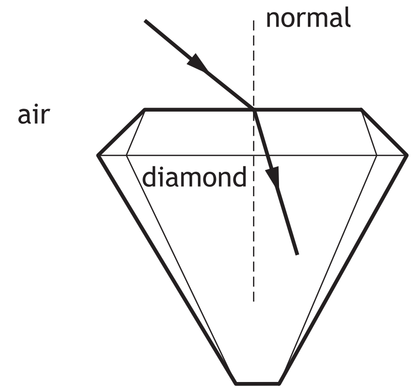
[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

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**

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

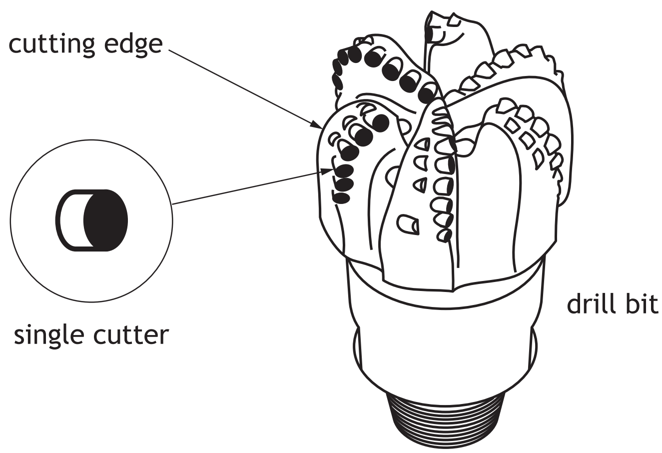
MARKS DO NOT WRITE IN THIS MARGIN

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

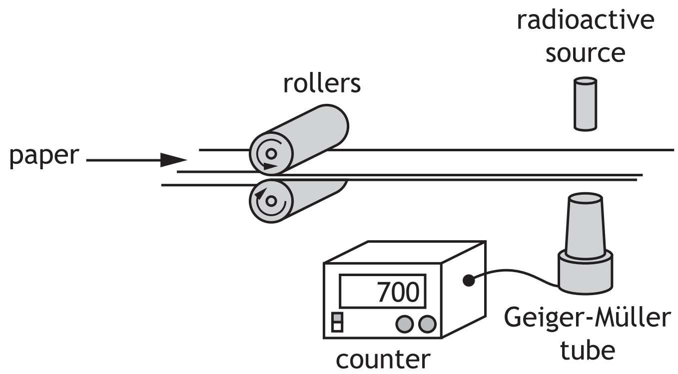
[Turn over

X757750115

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**

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

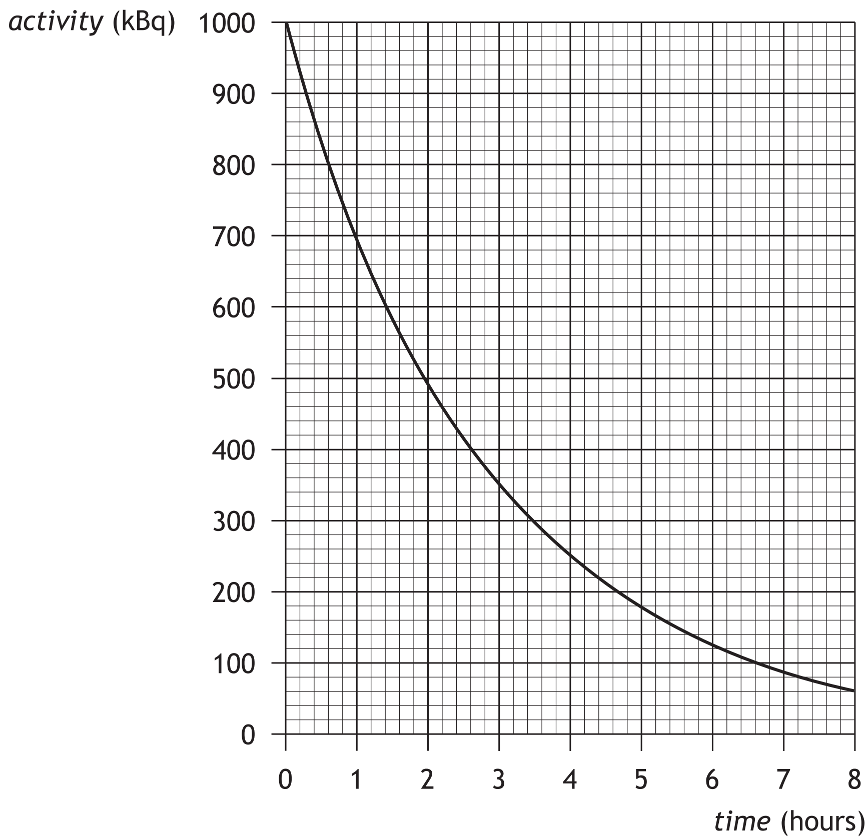
MARKS DO NOT WRITE IN THIS MARGIN

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

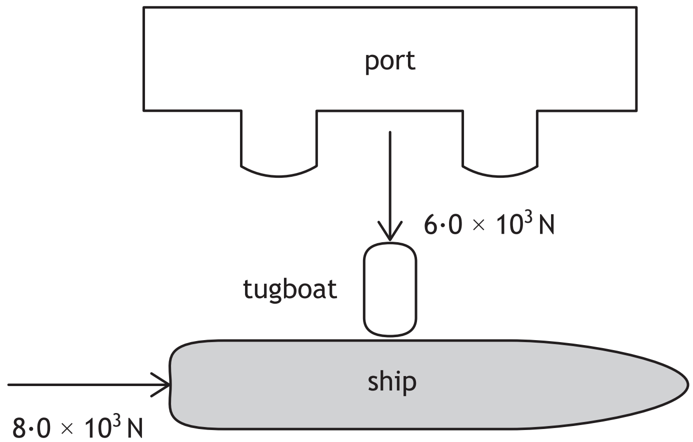
[Turn over

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

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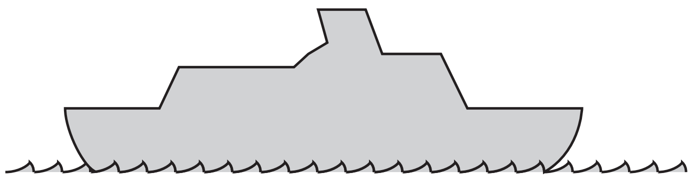
MARKS | DO NOT WRITE IN THIS MARGIN

7. (a) (continued)

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

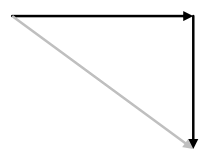
Space for working and answer

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



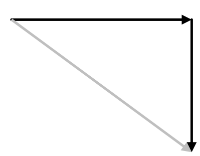
Explain, with the aid of a labelled diagram, why the ship floats. **3**

[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) $Resultant = 10 \times 10^3$ N (1) **Using scale diagram:**  vectors to scale (1) $Resultant = 10 \times 10^3$ 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

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Max Mark</th><th>Additional Guidance</th></tr>
<tr><td></td><td></td><td>(ii)</td><td>Using trigonometry:

tan θ = 6/8 (1)
θ = 37° (1)

Using scale diagram:

angles correct (1)
θ = 37° (1)
(allow ±2° tolerance)</td><td>2</td><td>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

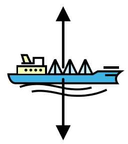
allow 1-4 sig fig:
40°
37°
36·9°
36·87°

Must be an attempt to calculate the angle relative to the 8·0 × 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)

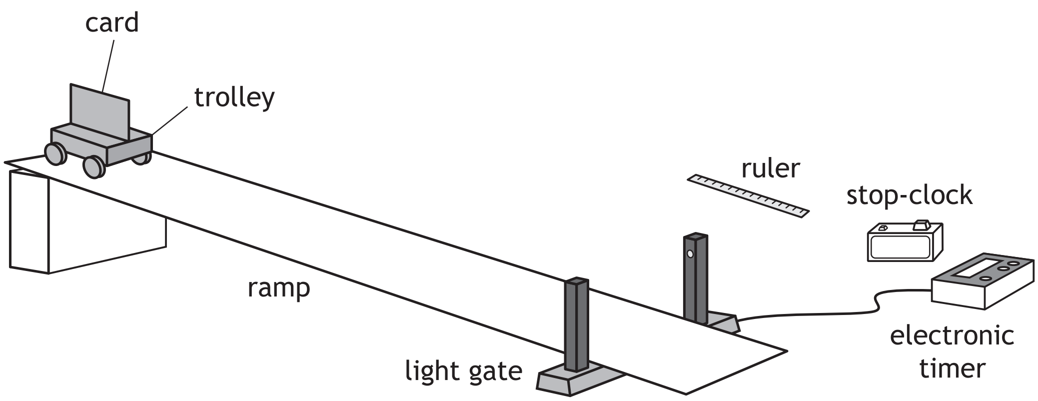
can obtain first mark for scale diagram method from suitable diagram in part (a) (i) if not drawn in this part</td></tr>
</table>

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.

(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**

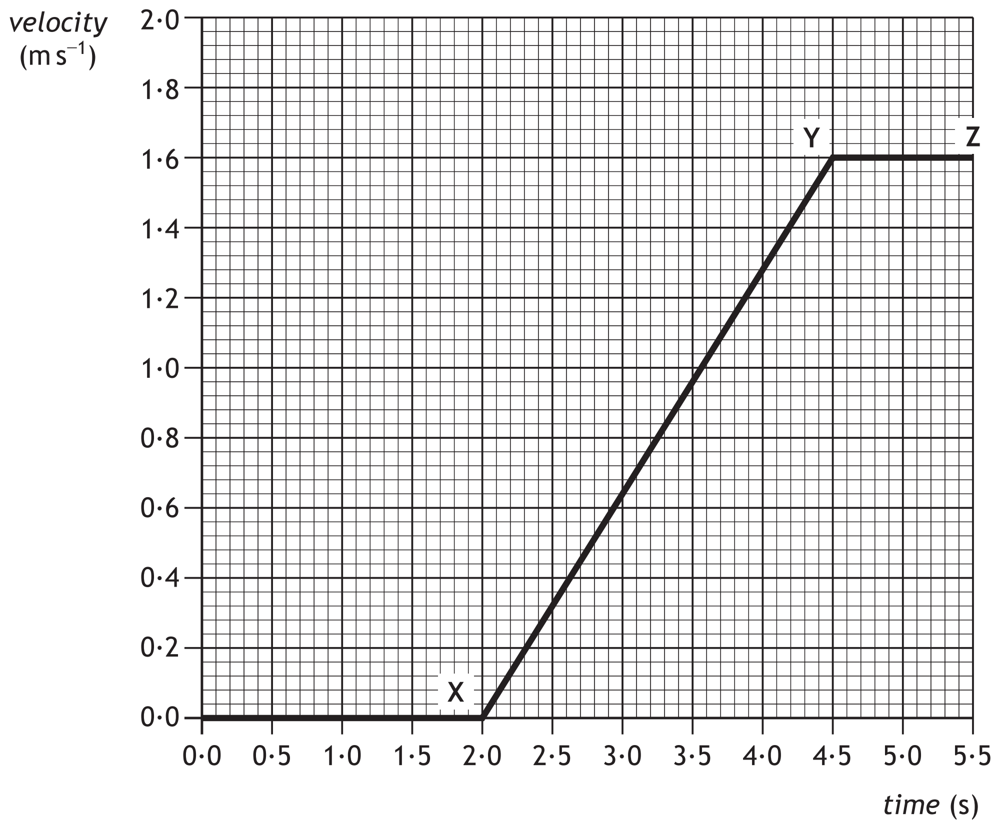
(ii) Suggest one reason why the acceleration calculated from these measurements might not be accurate. **1**

Back to Table

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

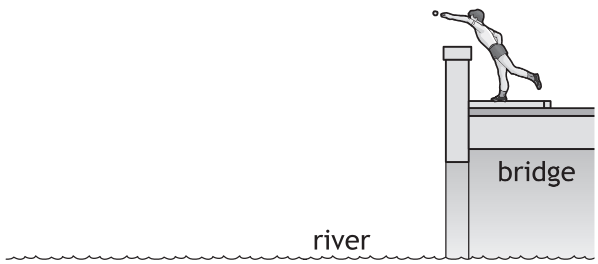
* X 7 5 7 7 5 0 1 2 1 *

Back to Table

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 0·6 m s^{-2}

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

MARKS | DO NOT WRITE IN THIS MARGIN



(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**

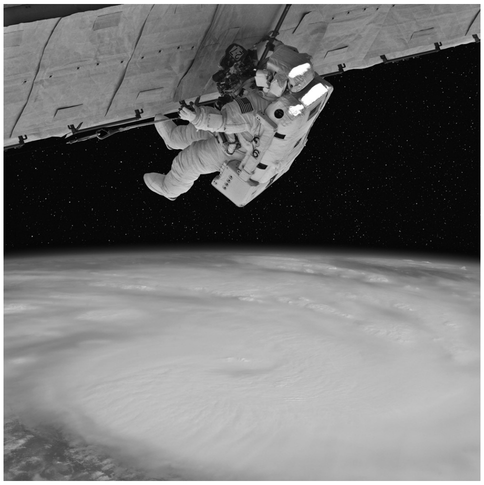
* X 7 5 7 7 5 0 1 2 2 *

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} 7·8 m s^{-1} 7·84 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.

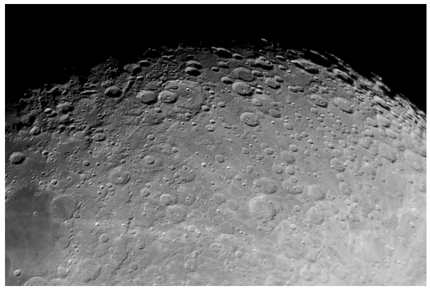


Using your knowledge of physics, comment on the benefits and/or risks of space exploration. **3**

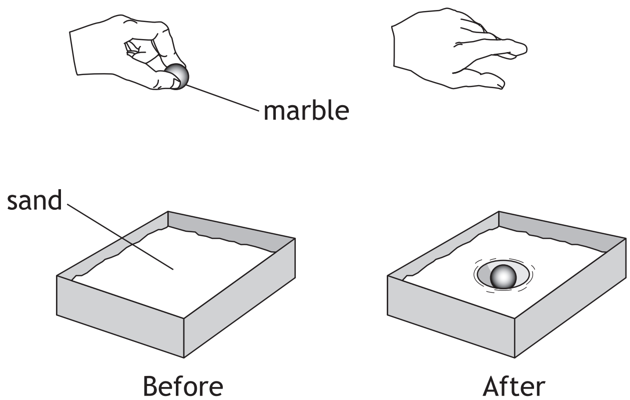
[Turn over

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

11. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

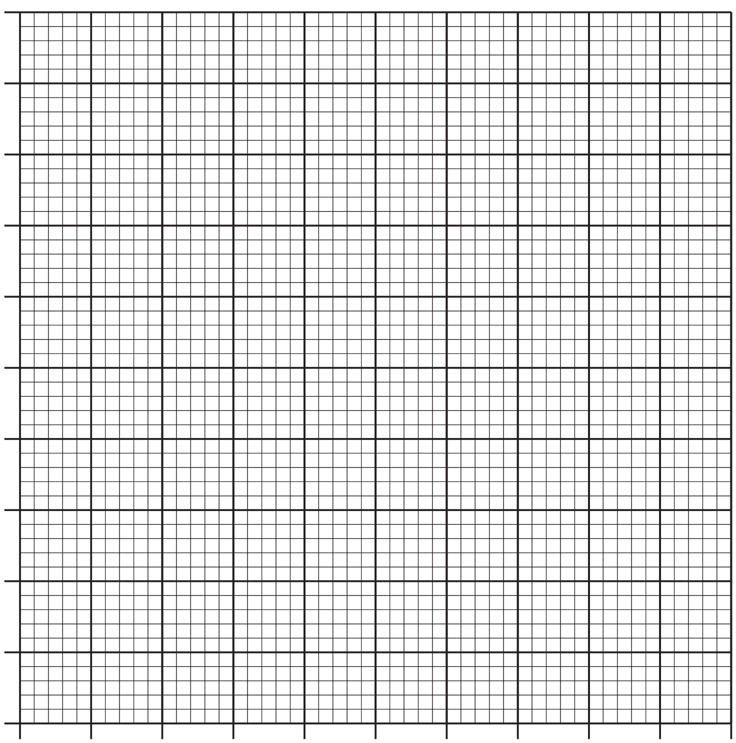
(b) The student drops the marble from different heights and measures the diameter of each crater that is formed.

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]

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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.

SQA ©

* X 7 5 7 7 5 0 2 *

A/PB

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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

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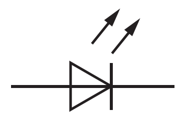
SECTION 1

Attempt ALL questions

1. The symbol for an electronic component is shown.



This is the symbol for

A an LDR

B a transistor

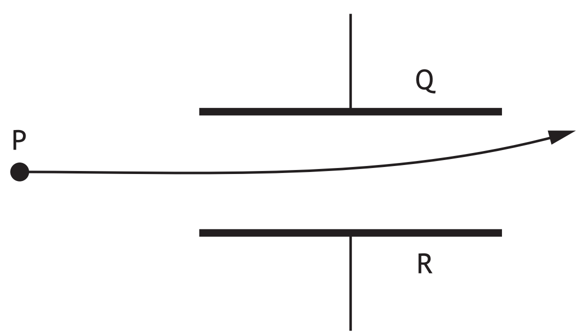
C an LED

D a photovoltaic cell

E a thermistor.

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

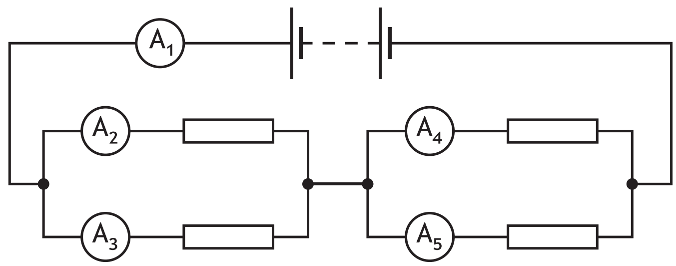
The diagram shows the path taken by a particle as it passes through the field.



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.

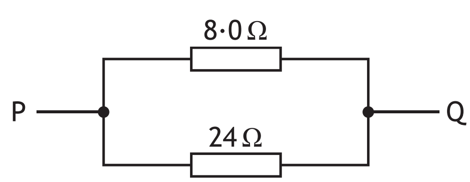
The reading on ammeter A_2 is 2·0 A.

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

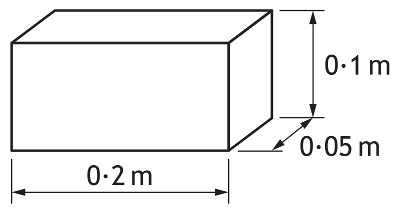
B 3·0 Ω

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

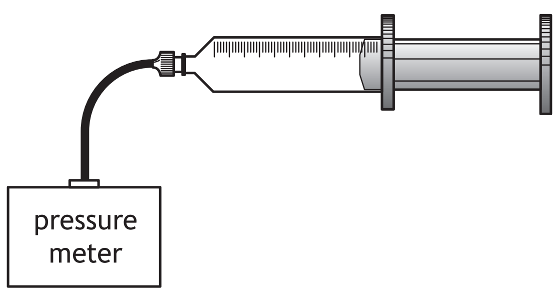
B 245 Pa

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

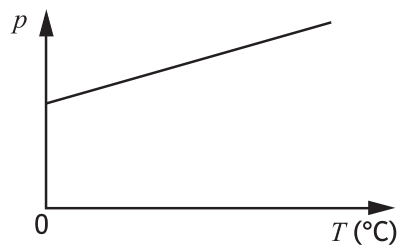
D 80 000 kPa

E 180 000 kPa.

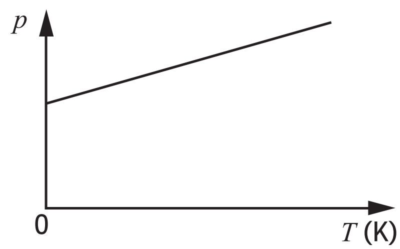
7. A sample of an ideal gas is enclosed in a sealed container.

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

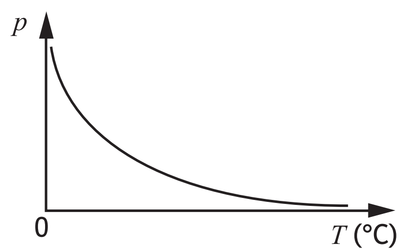
A



B



C



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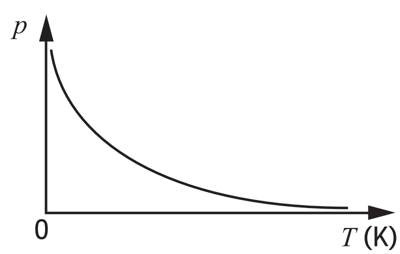
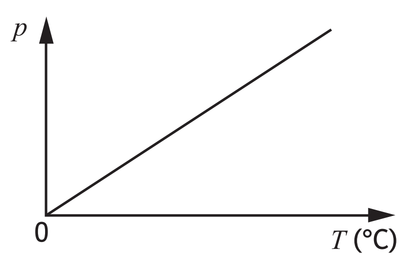


E



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

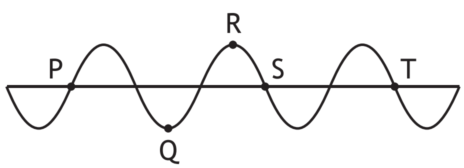
B II only

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

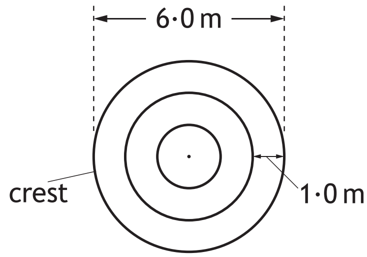
C Q and R

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.



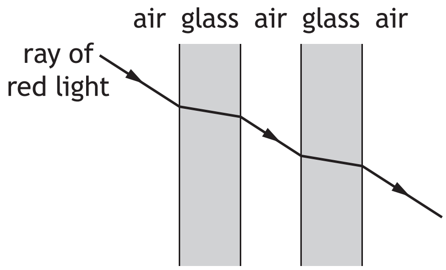
Which row in the table shows the speed and the frequency of the waves?

	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

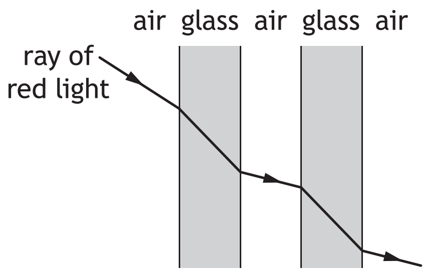
11. A ray of red light passes through a double glazed window.

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

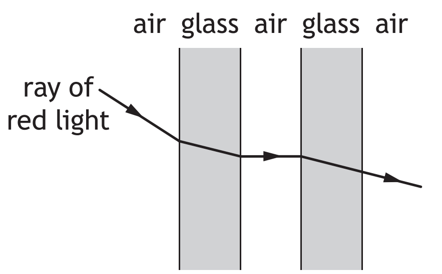
A



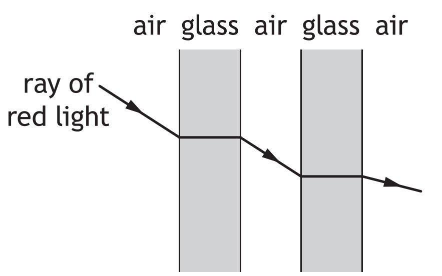
B



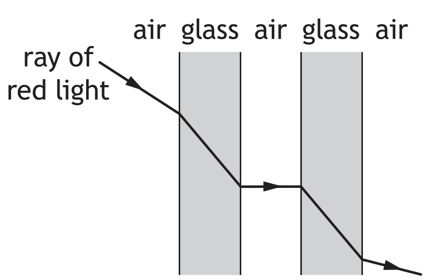
C



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

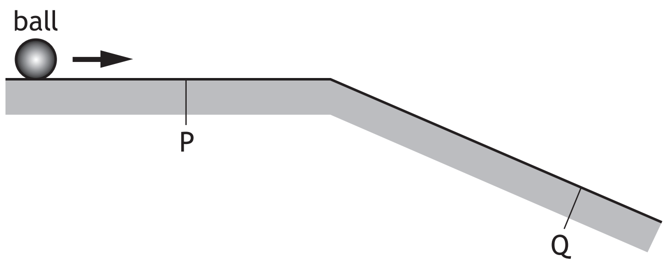
B Time

C Speed

D Kinetic energy

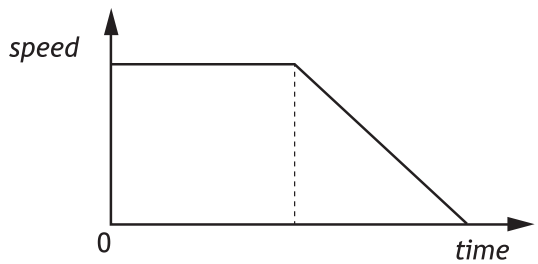
E Acceleration

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

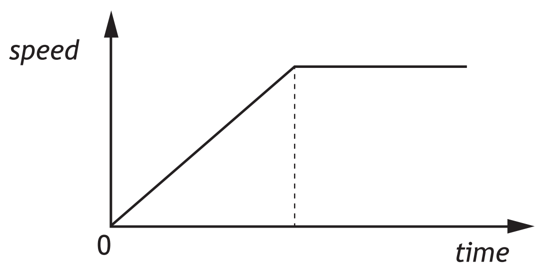


Which of the following graphs shows how the speed of the ball varies with time as it travels from P to Q?

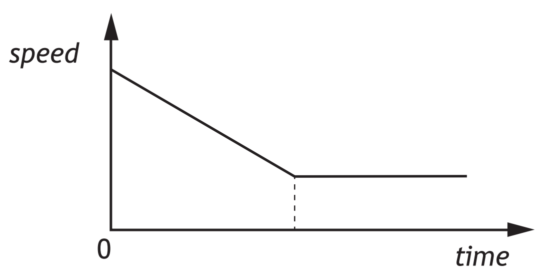
A



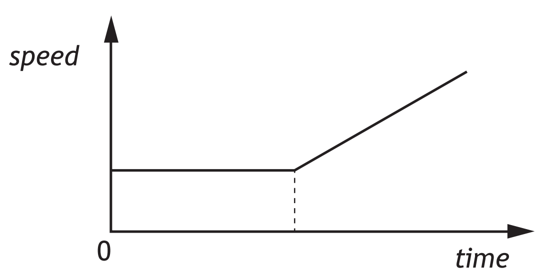
B



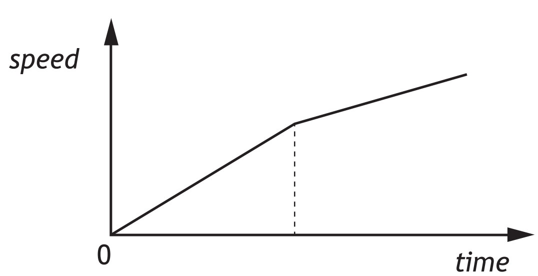
C



D



E



[Turn over

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.

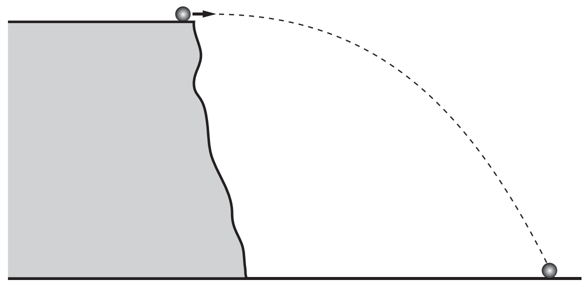
B The force of the Earth on the rocket engines.

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 $1{\cdot}5\,\mathrm{m\,s^{-1}}$ from a cliff as shown.



The ball hits the ground 1·2 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 ($\mathrm{m\,s^{-1}}$)	*Vertical velocity* ($\mathrm{m\,s^{-1}}$)
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.

Back to Table

[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**

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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.

SQA ©

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

A/PB

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**

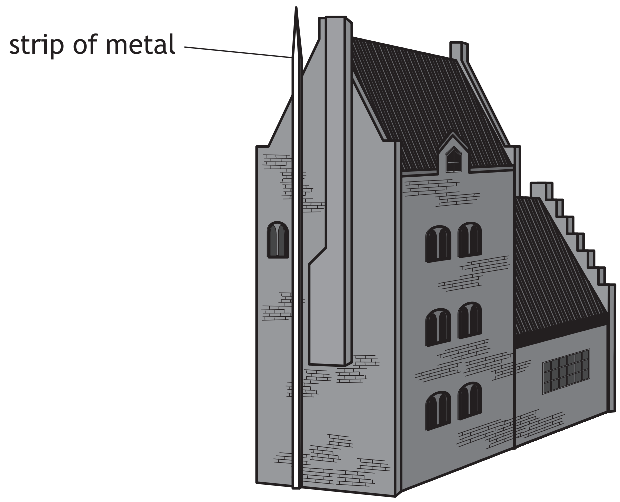
Space for working and answer

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

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.



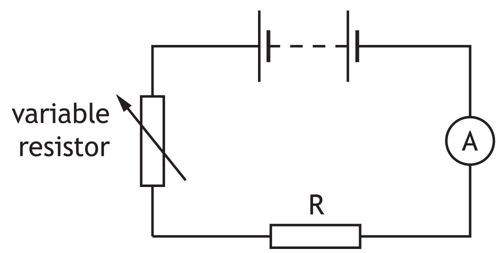
This strip is used to protect the building from damage during electrical storms.

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

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'

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**

MARKS | DO NOT WRITE IN THIS MARGIN

2. (continued)

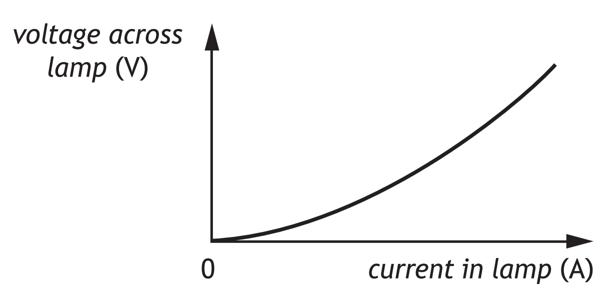
(c) The results of the student's investigation are shown.

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

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

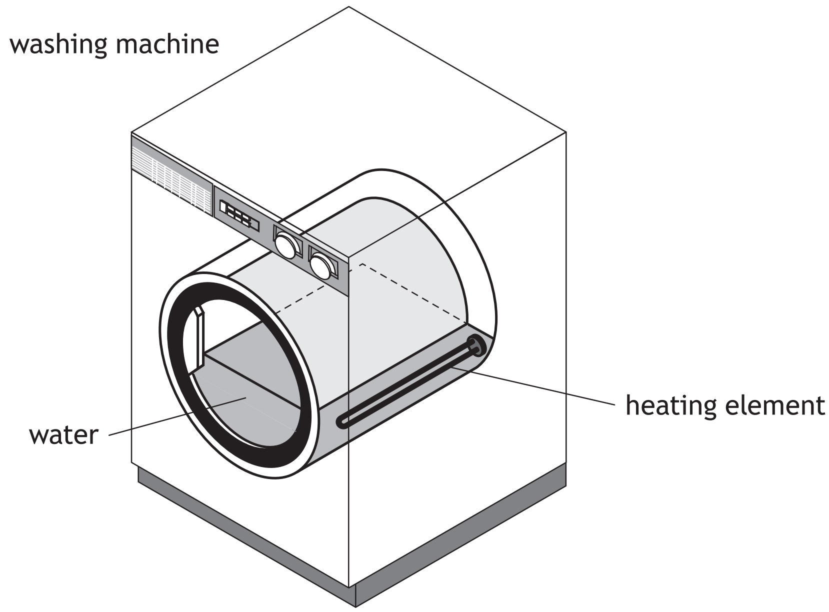
2.	(a)		Voltmeter across resistor R (1)	**1**	Correct symbol must be used.
	(b)		increase/decrease/vary/change the resistance of the variable resistor	**1**	Accept: 'change the number of cells/batteries' 'use batteries with different voltages' Do not accept: 'change the voltage of the battery'

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'

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

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**

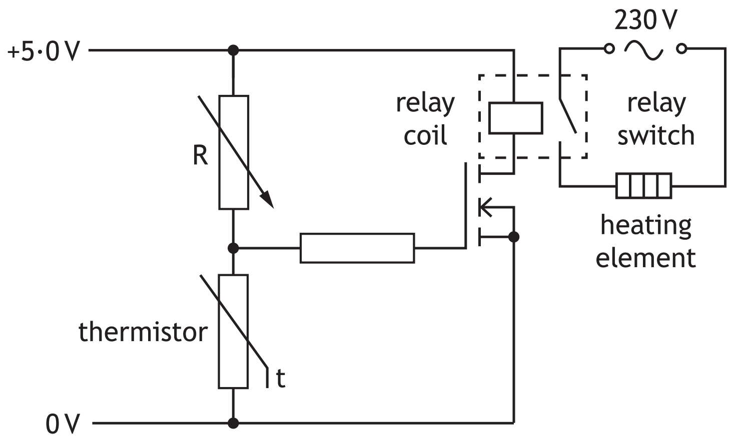
Space for working and answer

(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.

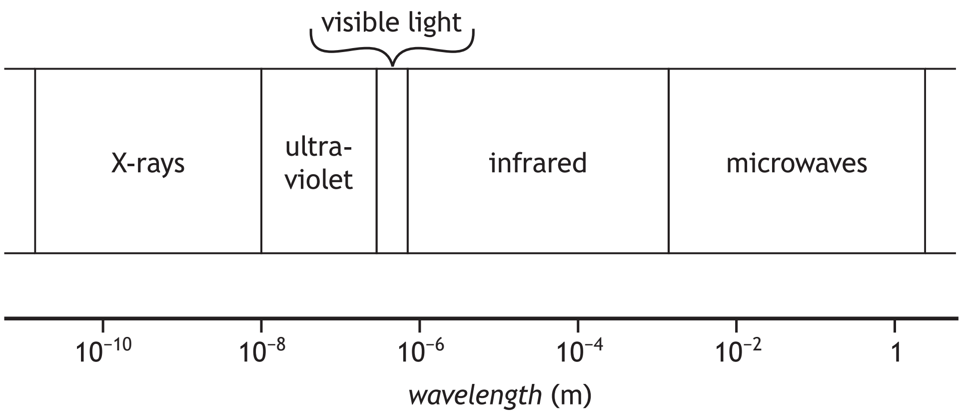
Explain how the circuit operates to **switch off** the heating element. **3**

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)	<u>Heat</u> (energy) is lost (from the water) to the washing machine/drum /surroundings/clothing **OR** Some of the energy is used to <u>heat</u> 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) $3\cdot0\times10^8 = 1\cdot2\times10^9\times\lambda$ (1) $\lambda = 0\cdot25$ 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**

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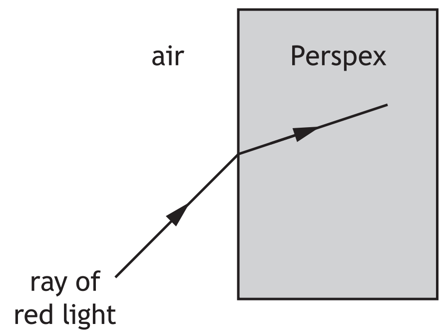
MARKS | DO NOT WRITE IN THIS MARGIN

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



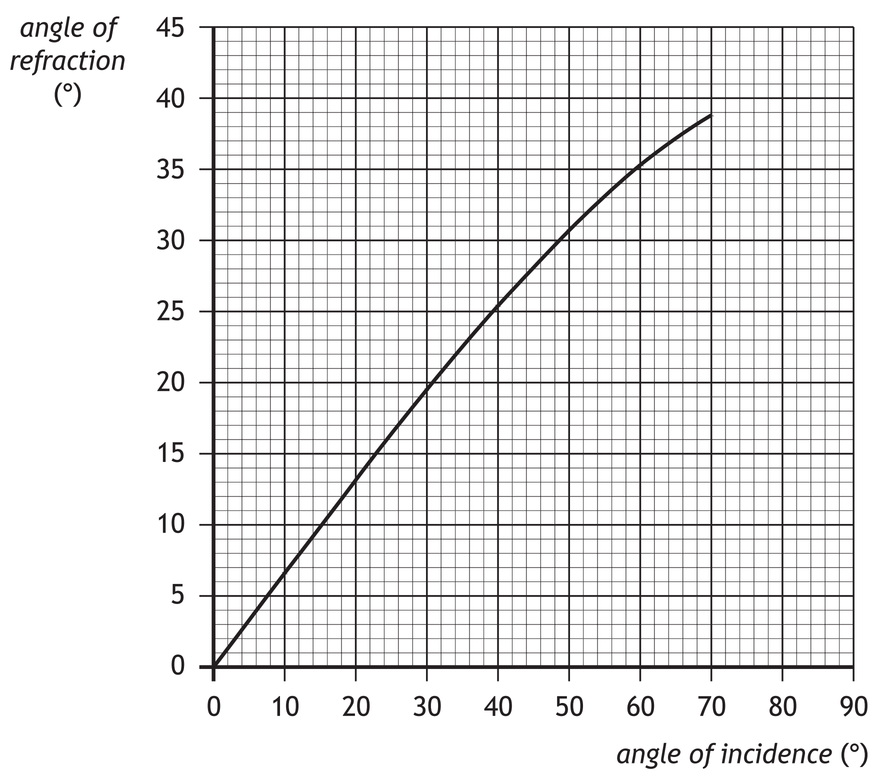
(a) On the diagram, draw and label:

(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.



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**

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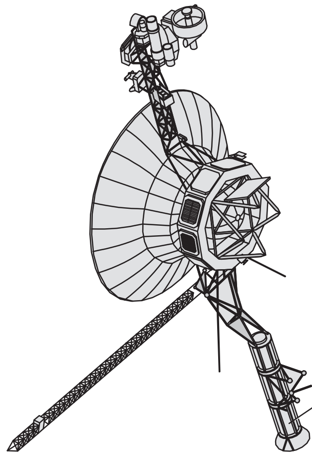
Question			Answer	Max Mark	Additional Guidance
6.	(a)	(i)	normal drawn and labelled	**1**	Must be 'passably' perpendicular and straight Does not need to be dashed Accept: 'N' or 'n' as label
		(ii)	Both angles indicated and labelled	**1**	Accept: i and r I and R θ_i and θ_r If normal has been incorrectly 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'

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

MARKS | DO NOT WRITE IN THIS MARGIN

7. (continued)

(c) Plutonium-238 emits alpha radiation.

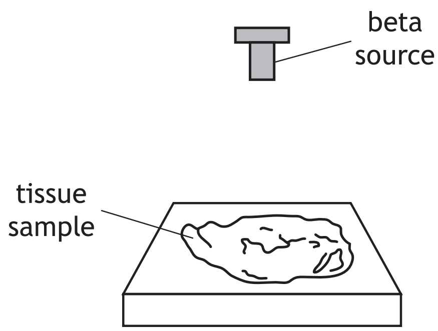
Explain why a source that emits alpha radiation requires less shielding than a source that emits gamma radiation. **1**

Question			Answer	Max Mark	Additional Guidance
7.	(a)		$A=\frac{N}{t}$ (1) $A=\frac{7\cdot92\times10^{18}}{900}$ (1) $A=8\cdot8\times10^{15}$ Bq (1)	**3**	Accept: 9×10^{15} Bq **OR** $A=\frac{N}{t}$ (1) $A=\frac{7\cdot92\times10^{18}}{15}$ (1) $A=5\cdot28\times10^{17}$ decays per min (1)
	(b)		$8\cdot8\times10^{15}\times4\cdot49\times10^{-14}$ (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 $P=\frac{7\cdot92\times10^{18}\times4\cdot49\times10^{-14}}{900}$ (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

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.

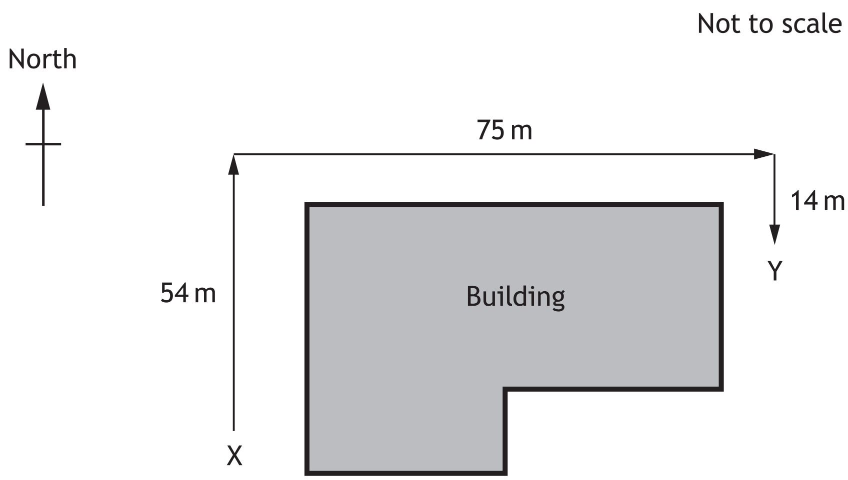
Determine the activity of the source 144 hours later. **3**

Space for working and answer

Question			Answer	Max Mark	Additional Guidance
8.	(a)	(i)	$D = \frac{E}{m}$ (1) $D = \frac{9 \cdot 6 \times 10^{-5}}{0 \cdot 5}$ (1) $D = 1 \cdot 9 \times 10^{-4}$ Gy (1)	**3**	Accept: 2×10^{-4} Gy $1{\cdot}9 \times 10^{-4}$ Gy $1{\cdot}92 \times 10^{-4}$ Gy $1{\cdot}920 \times 10^{-4}$ Gy Accept: J kg^{-1}
		(ii)	$H = Dw_R$ (1) $H = 1 \cdot 9 \times 10^{-4} \times 1$ (1) $H = 1 \cdot 9 \times 10^{-4}$ 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) $= 0 \cdot 75$ 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

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MARKS | DO NOT WRITE IN THIS MARGIN

9. (continued)

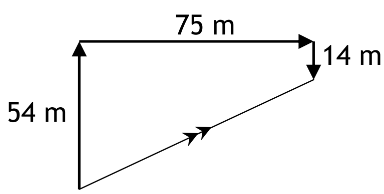
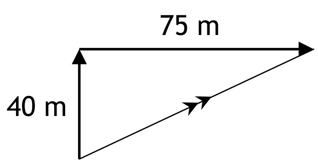
(b) The student takes 68 s to travel from point X to point Y.

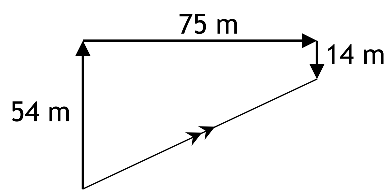
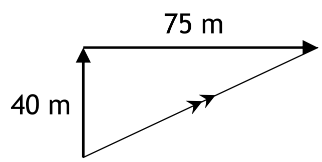
(i) Determine the average velocity of the student from point X to point Y. **3**

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:** $Resultant^2 = 40^2 + 75^2$ (1) Resultant = 85 m (1)	**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.
			Using scale diagram:  **or** 		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.
			Vectors to scale (1) Resultant = 85 m (1) (allow ±5 m tolerance)		

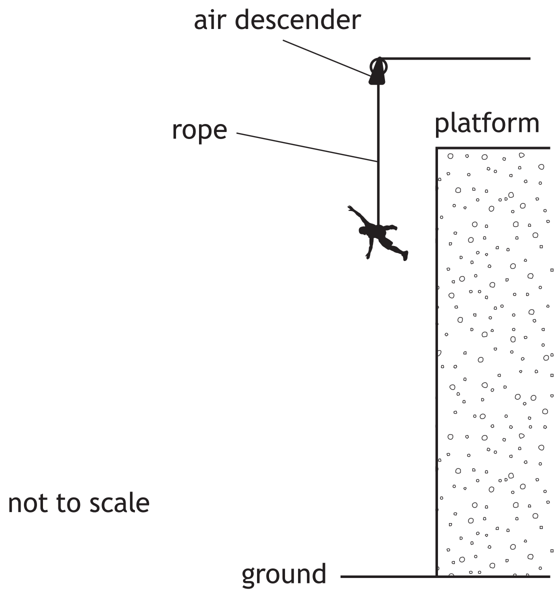
Question			Answer	Max Mark	Additional Guidance
		(ii)	**Using trigonometry:** $\tan\theta = \dfrac{75}{40}$ (1) $(\theta = 62°)$ direction = 062 (1) **Using scale diagram:**  **or**  Angles correct (1) direction = 062 (1) (allow $\pm 2°$ tolerance)	**2**	Or use of <u>resultant</u> value (and appropriate 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)).

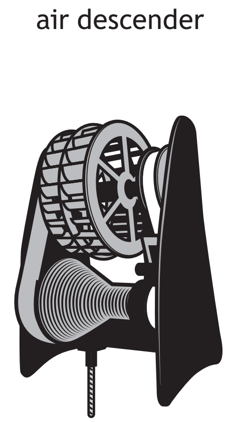
Question			Answer	Max Mark	Additional Guidance
	(b)	(i)	$\bar{v} = \frac{s}{t}$ (1) $\bar{v} = \frac{85}{68}$ (1) $\bar{v} = 1 \cdot 3 \text{m s}^{-1}$ at bearing 062 (1)	**3**	Or consistent with part (a) for magnitude and direction Must have direction for final mark. Accept: 1 m s $^{-1}$ 1·3 m s^{-1} 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

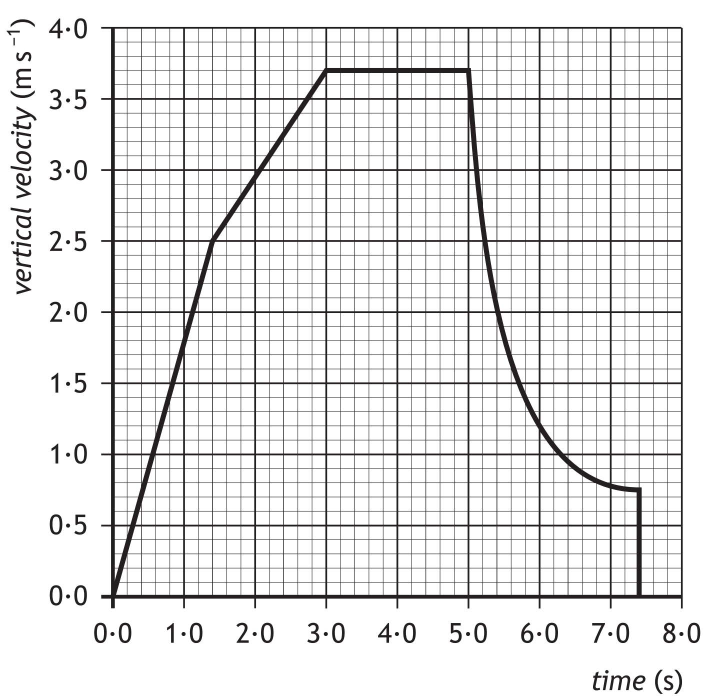
10. An air descender is a machine that controls the rate at which a climber drops from a platform at the top of a climbing wall.

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.



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

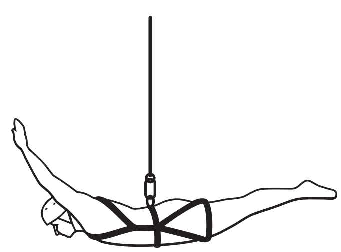
(b) Calculate the distance the climber drops during the first 3·0 s. **3**

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*)

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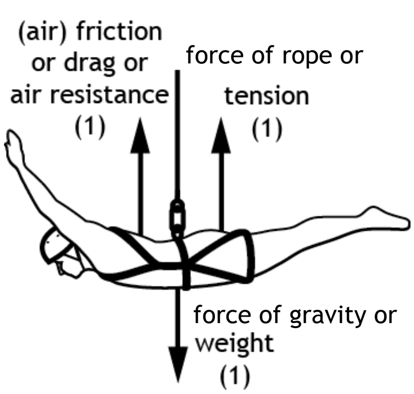
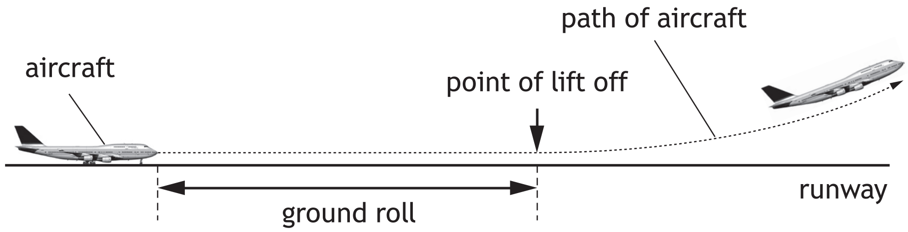
Question			Answer	Max Mark	Additional Guidance
10.	(a)		$a=\frac{v-u}{t}$ (1) $a=\frac{2\cdot5-0}{1\cdot4}$ (1) $a=1\cdot8\text{ m s}^{-2}$ (1)	**3**	Accept: $a=\frac{\Delta v}{t}$ $v=u+at$ Do not accept a response starting with: $a=\frac{v}{t}$ **OR** $v=at$ Accept: 2 m s^{-2} 1·8 m s^{-2} 1·79 m s^{-2} 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.

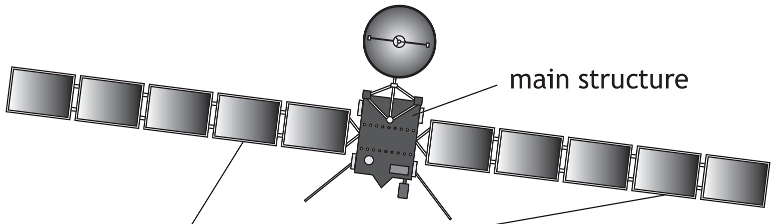


The ground roll of an aircraft varies for each take-off.

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	$1·23 \times 10^3$ kg $0·10 \times 10^3$ kg $1·67 \times 10^3$ kg
	Total	$3·00 \times 10^3$ 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**

* X 7 5 7 7 5 0 1 2 8 *

MARKS | DO NOT WRITE IN THIS MARGIN

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

[Turn over for next question

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) $\rightarrow$ electrical (energy)	**1**	Accept: light $\rightarrow$ electric 'to' instead of arrow Do not accept: light $\rightarrow$ electricity solar $\rightarrow$ 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).

Back to Table

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

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Back to Table

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

A/PB

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

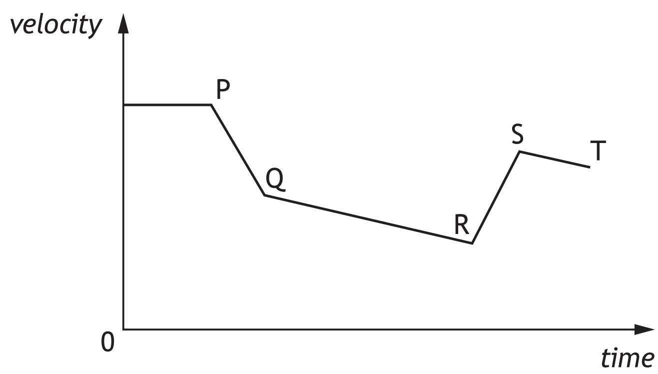
Radiation weighting factors

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

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

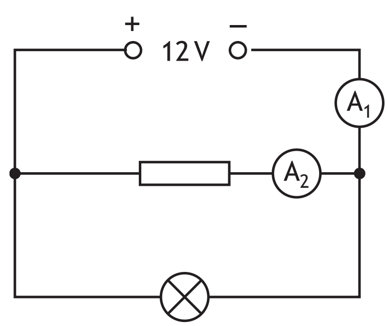
B Q

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

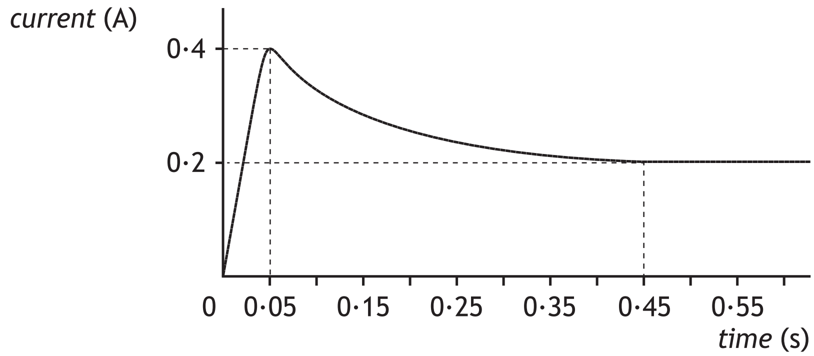
C 60 C

D 90 C

E 150 C.

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

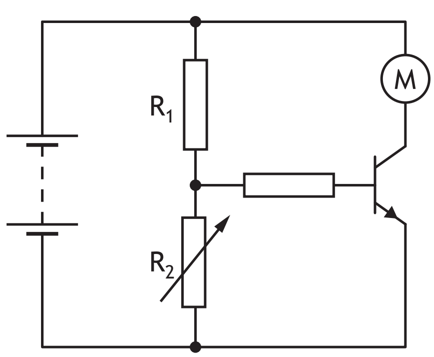
The graph shows how the current in the lamp varies with time.



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

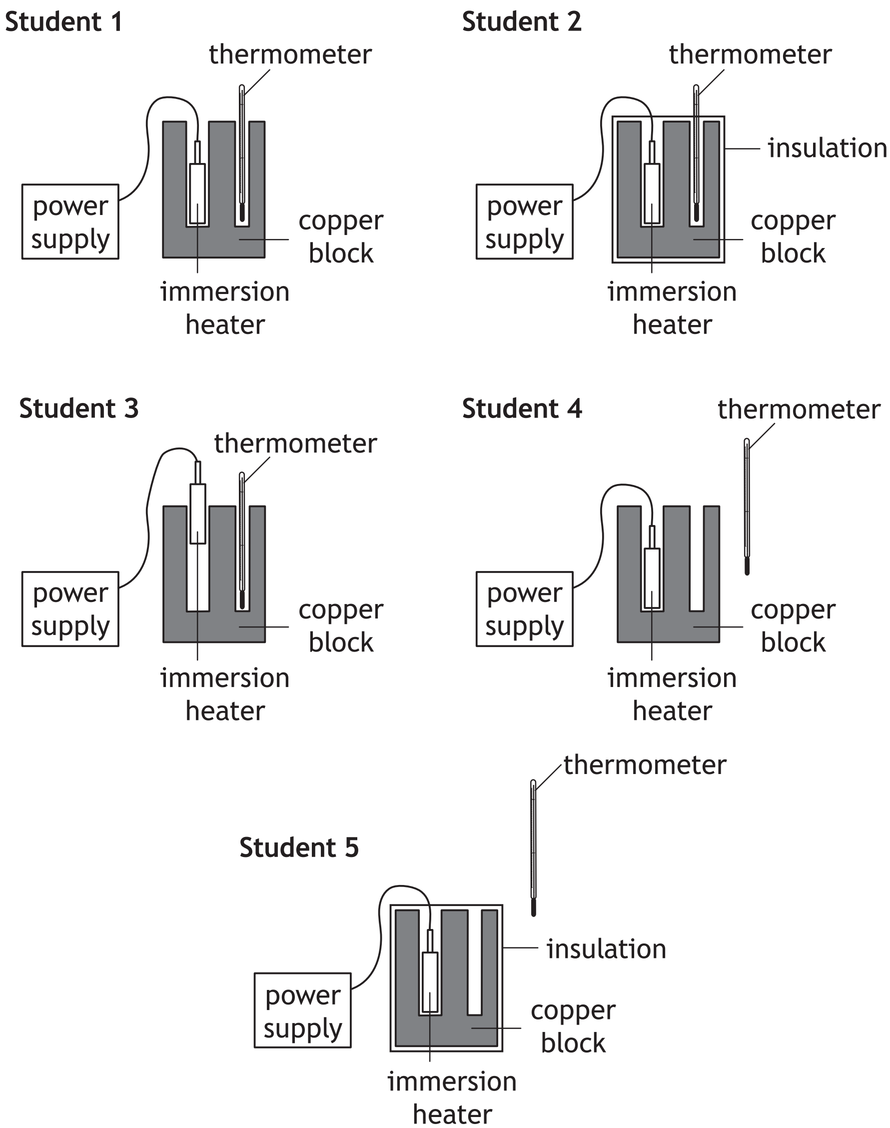
B decrease the voltage across R_1

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

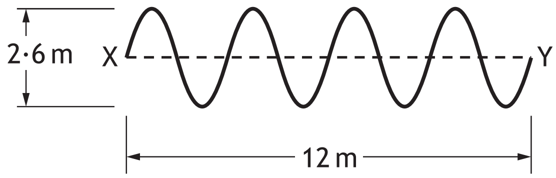
B II only

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

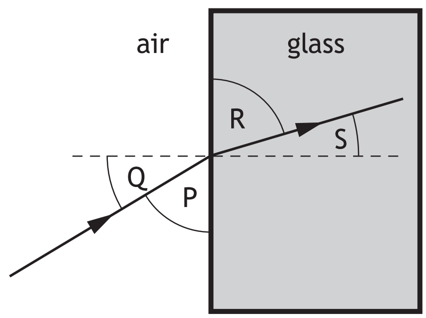
B ultraviolet

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

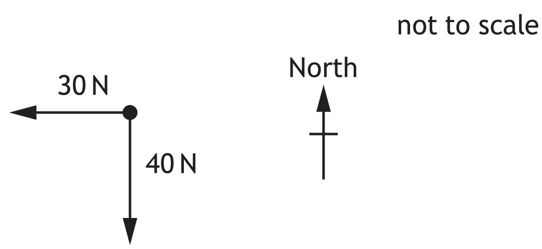
B 320 μSv

C 415 μSv

D 700 μSv

E 735 μSv.

14. Two forces act on an object as shown.



The resultant force acting on the object is

A 50 N at a bearing of 053

B 50 N at a bearing of 143

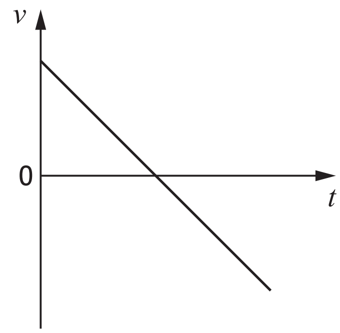
C 50 N at a bearing of 217

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

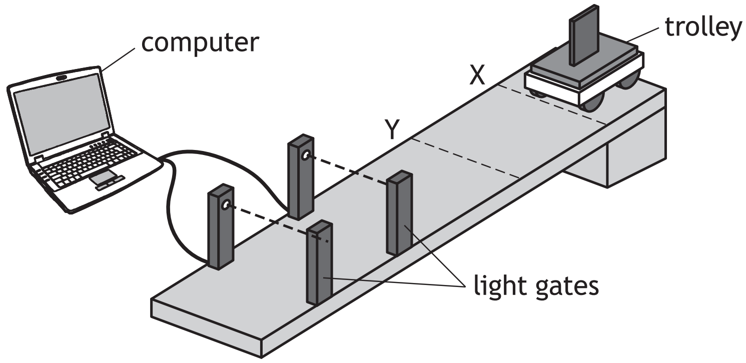
B a rocket accelerating upwards

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.

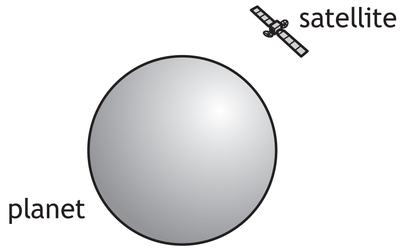
An identical rocket accelerates vertically upwards from the surface of Mars.

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**

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 *

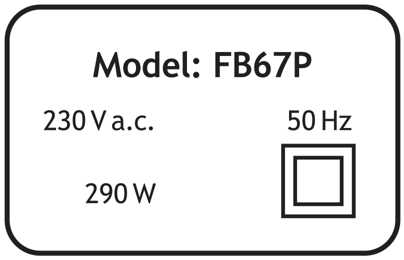
A/PB

MARKS DO NOT WRITE IN THIS MARGIN

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

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

MARKS | DO NOT WRITE IN THIS MARGIN

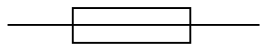
1. **(continued)**

(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**

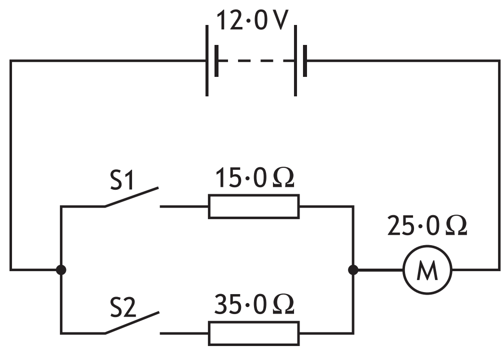
* X 7 5 7 7 5 0 1 0 7 *

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) $I = 1{\cdot}3\,(\mathrm{A})$ (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) $= 690\,(\mathrm{W})$ (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**

X757750109

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:** $V_2 = \left(\dfrac{R_2}{R_1 + R_2}\right) V_S$ (1) $= \left(\dfrac{25 \cdot 0}{25 \cdot 0 + 15 \cdot 0}\right) \times 12 \cdot 0$ (1) + (1) $= 7 \cdot 50\ V$ (1)
		(ii)	$P = \dfrac{V^2}{R}$ (1) $= \dfrac{7 \cdot 50^2}{25 \cdot 0}$ (1) $= 2 \cdot 25$ 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) $= 0 \cdot 300 \times 7 \cdot 50$ (1) $= 2 \cdot 25$ W (1) **Method 3:** $P = I^2 R$ (1) $= 0 \cdot 300^2 \times 25 \cdot 0$ (1) $= 2 \cdot 25$ W (1)

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>2.</td><td>(b)</td><td>(i)</td><td>$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ (1)
$= \frac{1}{15 \cdot 0} + \frac{1}{35 \cdot 0}$ (1)
$R_T = 10 \cdot 5\ \Omega$ (1)</td><td>3</td><td>Accept 2-5 sig fig:
11 Ω
10·50 Ω
10·500 Ω</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>(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)</td><td>3</td><td>Effect must be correct otherwise (0 marks)

Do not accept: ‘motor resistance is less’ for second mark

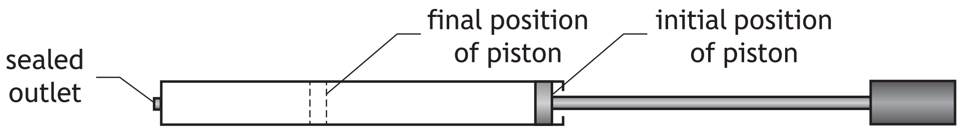
The effect can be established and/or justified by appropriate calculation(s). If this is done then effect must be correct for any marks to be awarded – award:
(1) for correct calculation of total resistance
(1) for correct voltage across motor or current in motor
(1) for correct power or statement that power is greater</td></tr>
</table>

MARKS | DO NOT WRITE IN THIS MARGIN

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

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

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

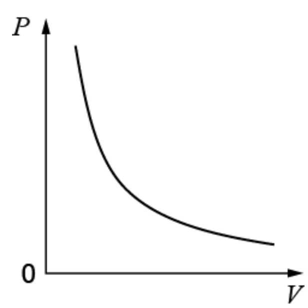
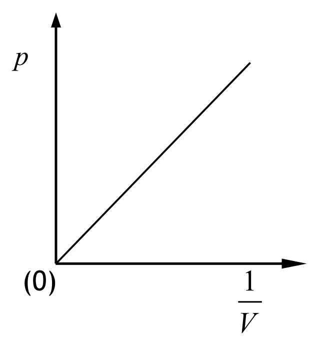
(c) The piston is now released, allowing it to move outwards towards its original position.

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.

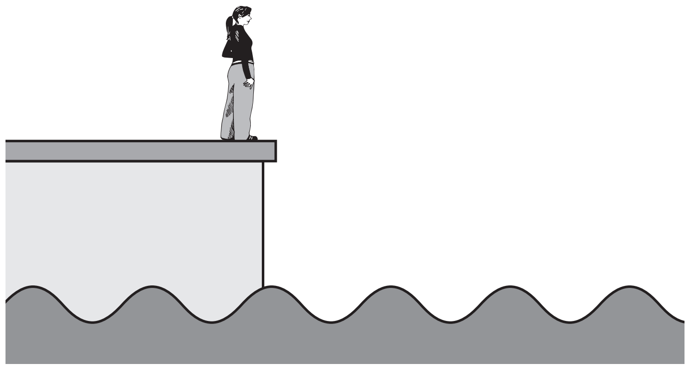
Numerical values are not required on either axis. **2**

(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**

X757750112

4. (continued)

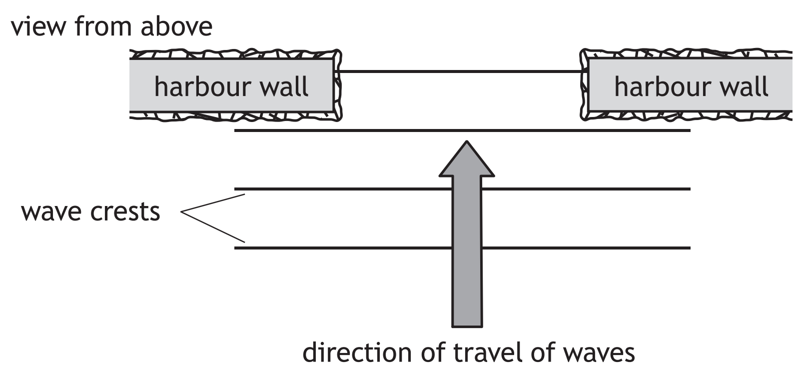
MARKS | DO NOT WRITE IN THIS MARGIN

(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.



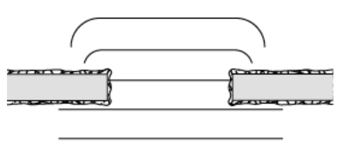
Complete the diagram to show the pattern of wave crests inside the harbour. **2**

(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**

Back to Table

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.

 Back to Table

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**

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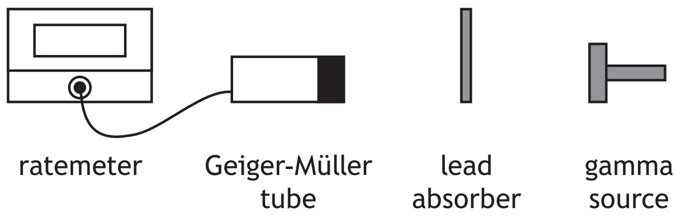
MARKS DO NOT WRITE IN THIS MARGIN

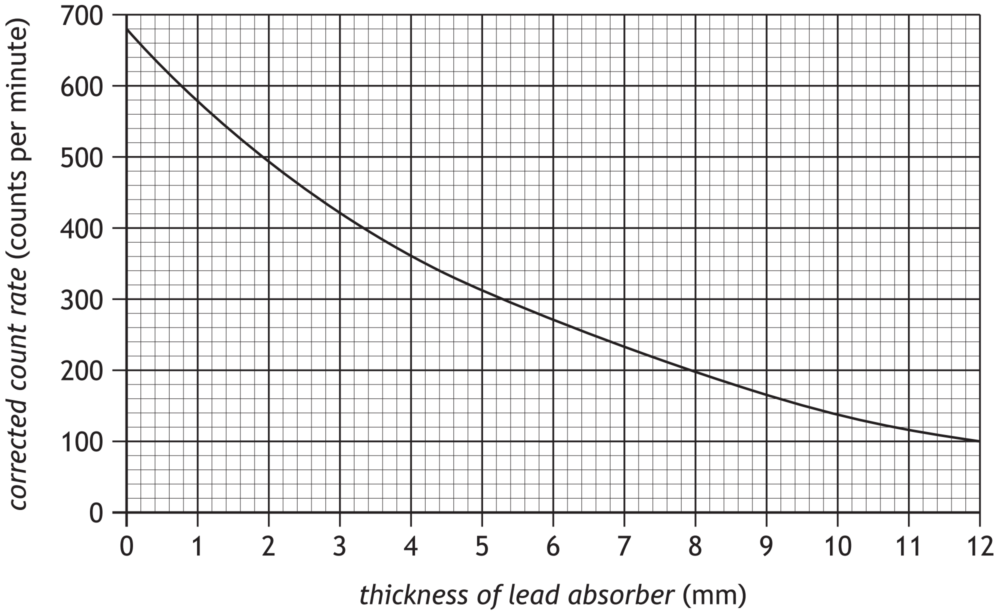
6. A technician uses the apparatus shown to investigate the effect of shielding gamma radiation with lead.



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**

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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 $2{\cdot}5 \times 10^{-6}\,\mathrm{Sv\,h^{-1}}$.

The annual equivalent dose limit for the technician is $20\,\mathrm{mSv}$.

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**	

MARKS DO NOT WRITE IN THIS MARGIN

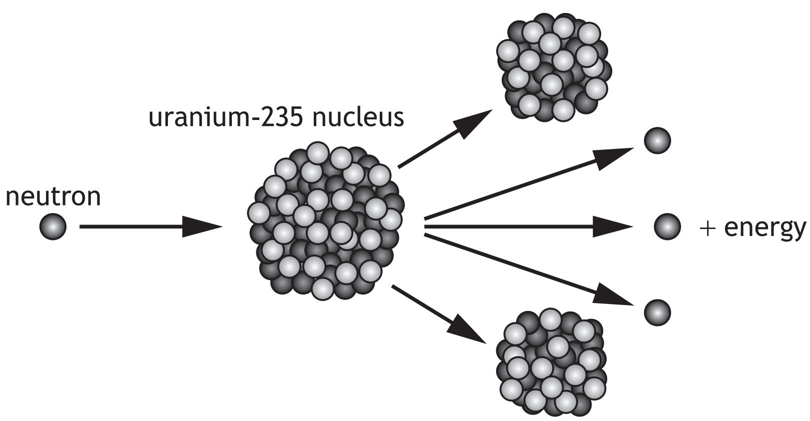
7. Nuclear reactions are used to generate electrical energy in a nuclear power station.

(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.



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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**

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>7.</td><td>(a)</td><td></td><td><u>80 000</u> (nuclei) decay(s) per unit time</td><td>1</td><td>Accept: ‘per second’ in place of ‘per unit time’</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td><u>neutrons</u> can go on to cause further (fission) reactions/split more (uranium) nuclei (1)

causing a chain reaction/this process repeats (1)</td><td>2</td><td>Independent marks.</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>$(E) = 3 \cdot 0 \times 10^{21} \times 3 \cdot 2 \times 10^{-11}$ (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)</td><td>4</td><td>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</td></tr>
<tr><td></td><td>(c)</td><td></td><td>any suitable use

(eg treating cancer/tracers/ sterilisation/smoke detectors/ measuring thickness of paper)</td><td>1</td><td>Must be a use of nuclear <u>radiation</u></td></tr>
</table>

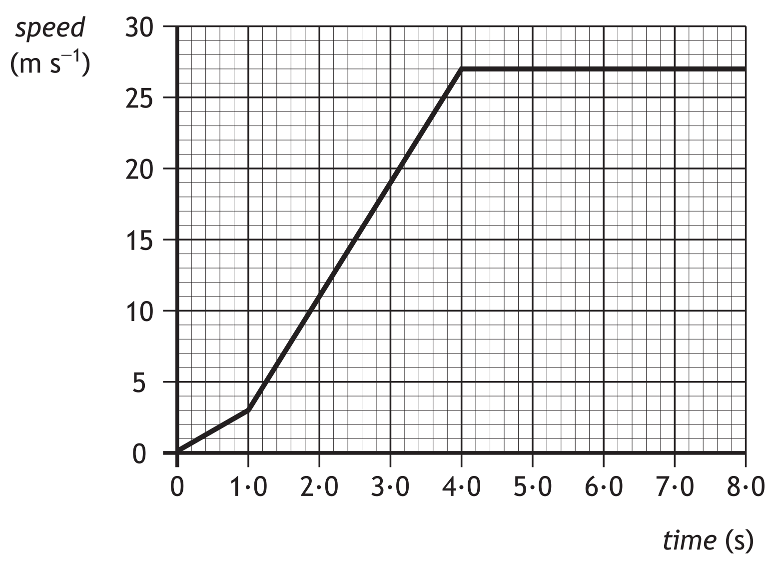
MARKS | DO NOT WRITE IN THIS MARGIN

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.



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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)	$a=\frac{v-u}{t}$ (1) $a=\frac{27-3}{3\cdot0}$ (1) $a=8$ 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 1-3 sig fig: 8·0 m s^{-2} 8·00 m s^{-2}
	(c)		$d=\bar{v}t$ (1) $4\times380=\bar{v}\times79$ (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

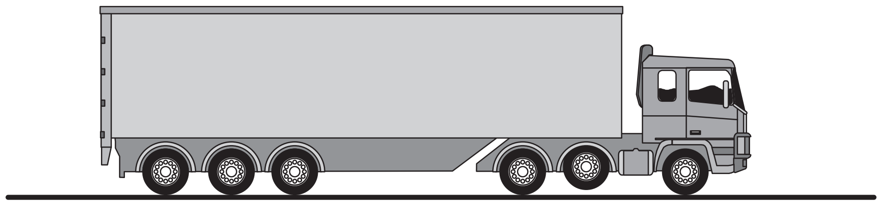
* X 7 5 7 7 5 0 1 2 2 *

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) $m = 120\ \text{kg}$ (1)	**3**	Use of $F=ma$ is wrong physics - award (0 marks)
	(c)		$F = 1344 - 1176 = 168\ (\text{N})$ (1) $F = ma$ (1) $168 = 120 \times a$ (1) $a = 1 \cdot 4\ \text{m s}^{-2}$ (1)	**4**	Or consistent with (b) Accept 1-4 sig fig: $1\ \text{m s}^{-2}$ $1{\cdot}40\ \text{m s}^{-2}$ $1{\cdot}400\ \text{m s}^{-2}$

MARKS DO NOT WRITE IN THIS MARGIN

10. An articulated lorry has six pairs of wheels.

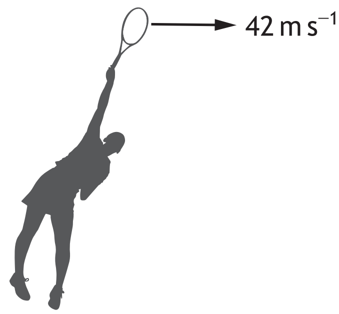
One pair of wheels can be raised off the ground.



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

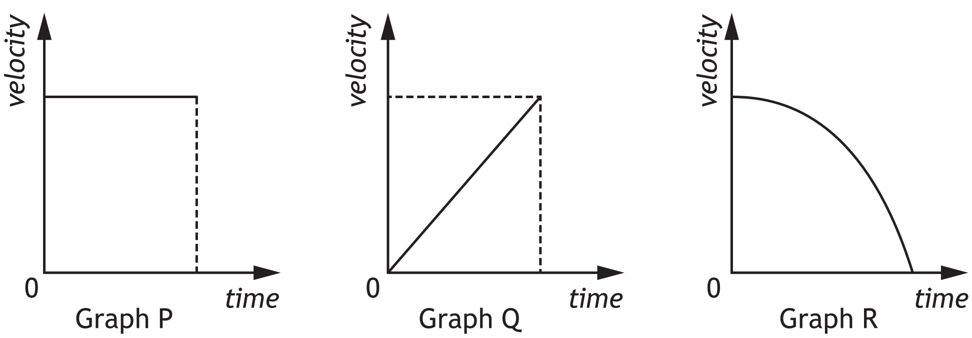
MARKS DO NOT WRITE IN THIS MARGIN

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

[Turn over for next question

Question			Answer	Max mark	Additional guidance
11.	(a)		Q	**1**	
	(b)		equal (to) (1) vertical/downward <u>acceleration</u> 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]

X757750126

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) $d = 3{\cdot}0 \times 10^8$ $\times(7{\cdot}8 \times 365{\cdot}25 \times 24 \times 60 \times 60)$ (1) $d = 7{\cdot}4 \times 10^{16}$ (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.

S857502

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

SECTION 1

Attempt ALL questions

1. Which of the following contains two scalar quantities?

A Force and mass

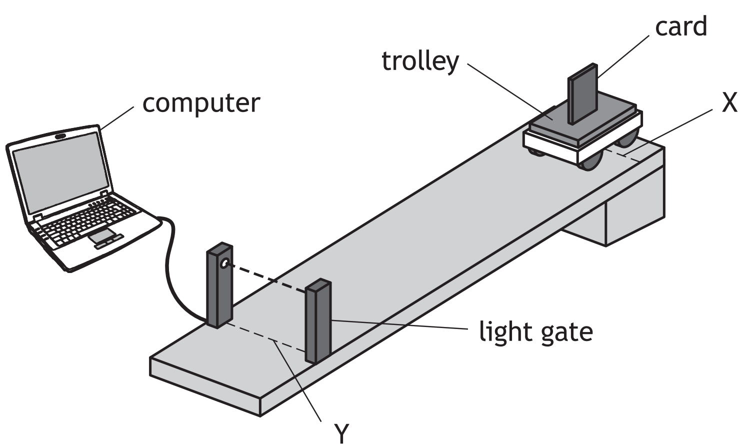
B Weight and mass

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}

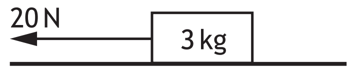
C 2·0 m s^{-1}

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

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 4·0 μA 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

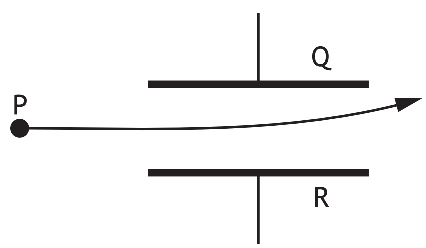
C $6{\cdot}25 \times 10^{1}$ C

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

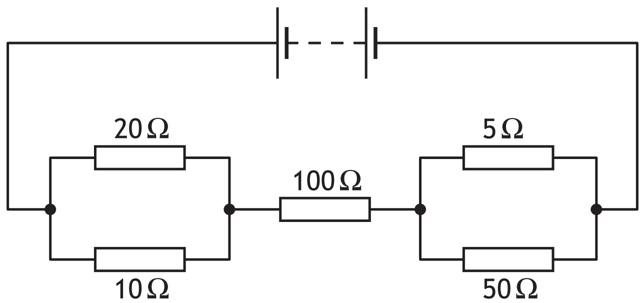
B 1 coulomb per second

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

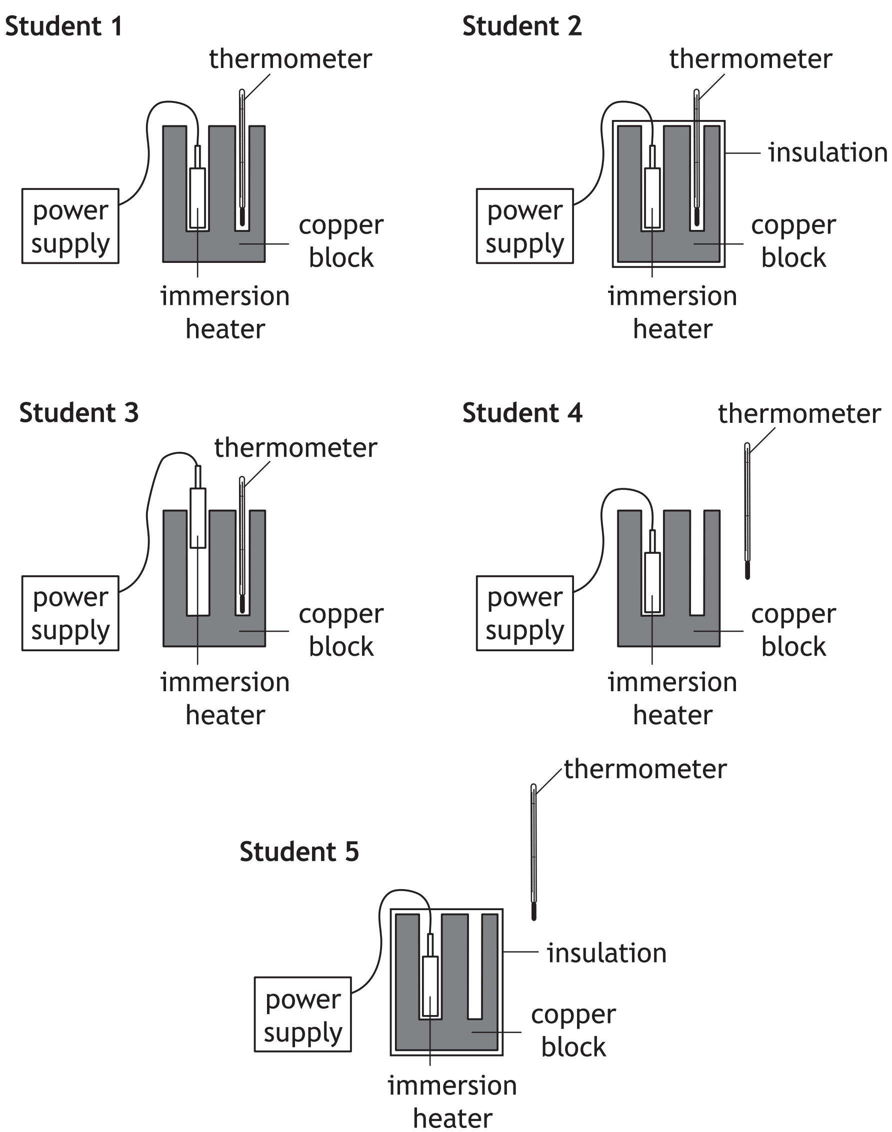
B 10 Ω

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

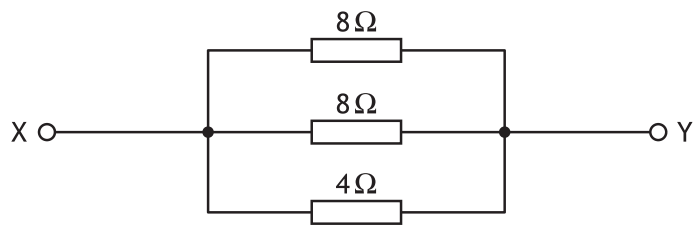
C student 3

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

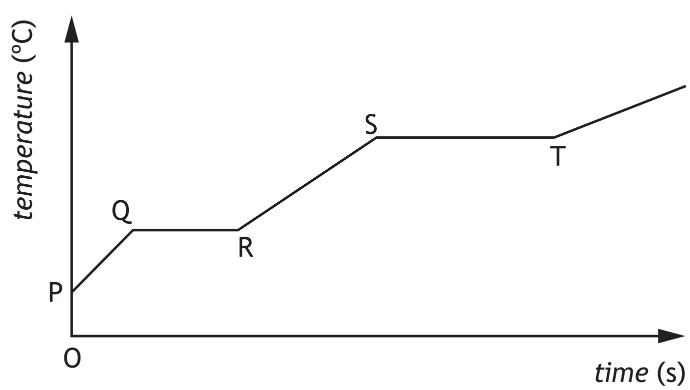
D 13 Ω

E 20 Ω.

15. A heater is immersed in a substance.

The heater is then switched on.

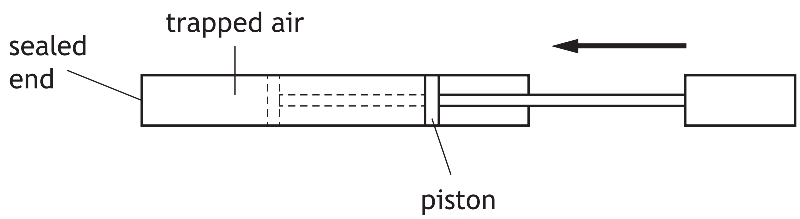
The graph shows the temperature of the substance over a period of time.



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 $5{\cdot}00 \times 10^{-4}\,m^2$.

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

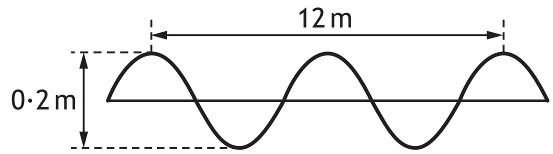
C 306 K

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.

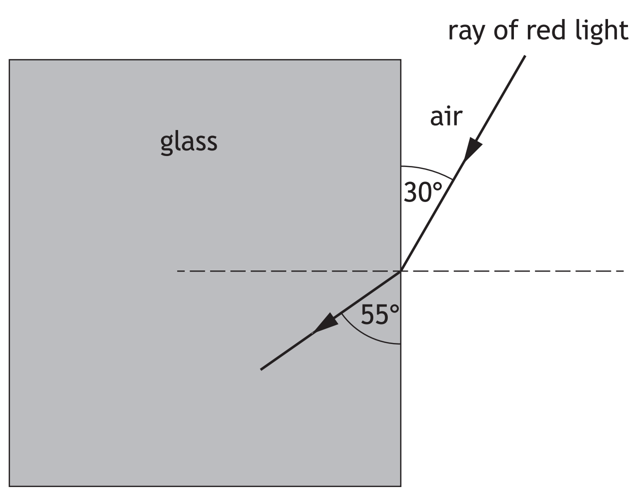
Gamma rays	P	Ultraviolet radiation	Q	Infrared radiation	R	TV and radio waves

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

* S 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 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.

SQA

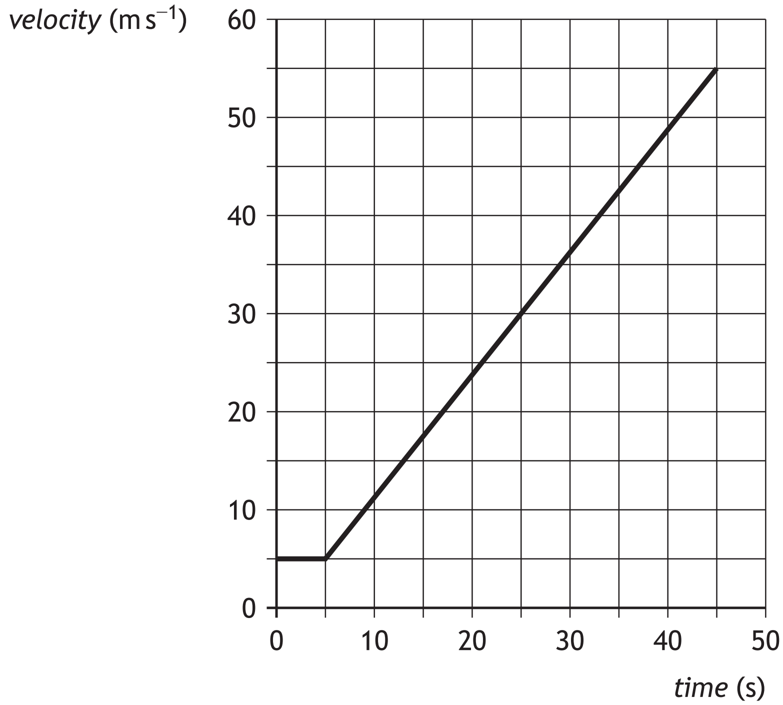
* S 8 5 7 7 5 0 1 0 1 *

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.



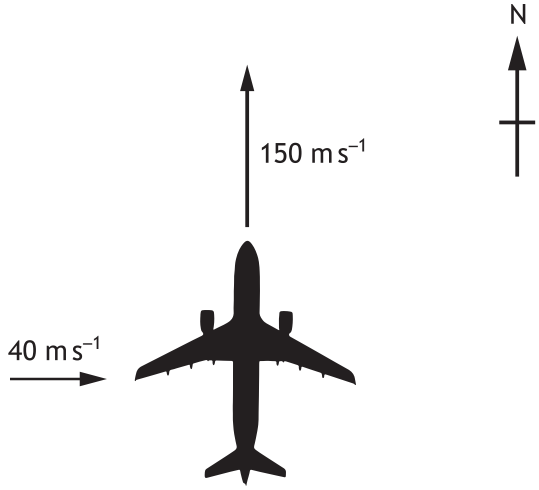
(a) Calculate the acceleration of the aircraft during take-off. **3**

Space for working and answer

1. **(continued)**

MARKS DO NOT WRITE IN THIS MARGIN

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

* S 8 5 7 7 5 0 1 0 6 *

1. (continued)

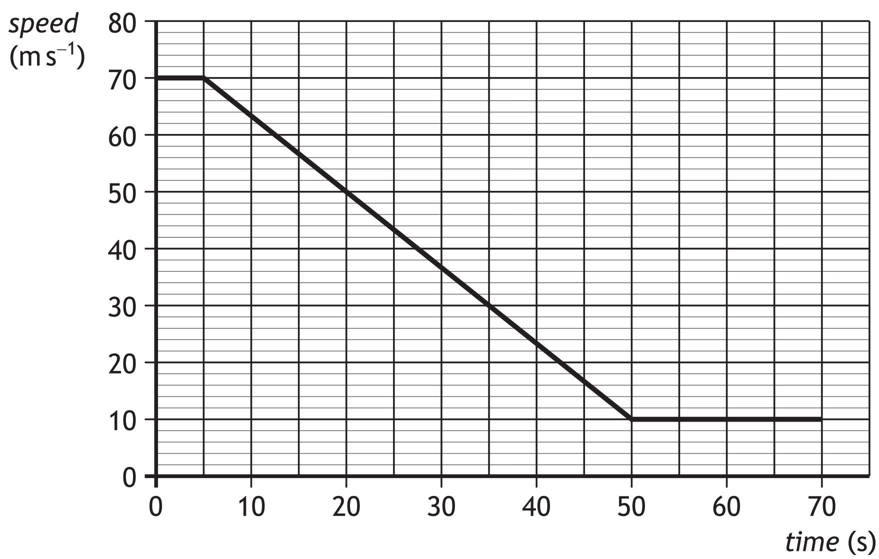
MARKS | DO NOT WRITE IN THIS MARGIN

(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

S857750107

[Turn over

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**

Section 2

<table>
<tr><th colspan="3">Question</th><th>Expected response</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>1.</td><td>(a)</td><td></td><td>

$a=\frac{v-u}{t}$ 1

$a=\frac{55-5}{40}$ 1

$a=1{\cdot}25\,\text{m s}^{-2}$ 1

</td><td>3</td><td>

Accept 1·3, 1·250, 1·2500

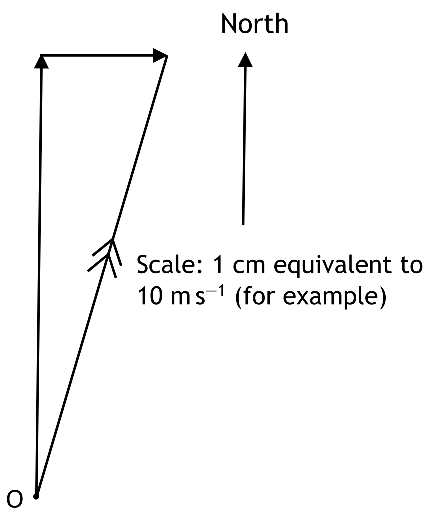
Accept
$a=$ gradient

and substitution of data points from appropriate line

</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>

Scale diagram

v=155±3 m s^{-1}



</td><td>2</td><td>

Pythagoras

$v=\sqrt{150^2+40^2}$ 1

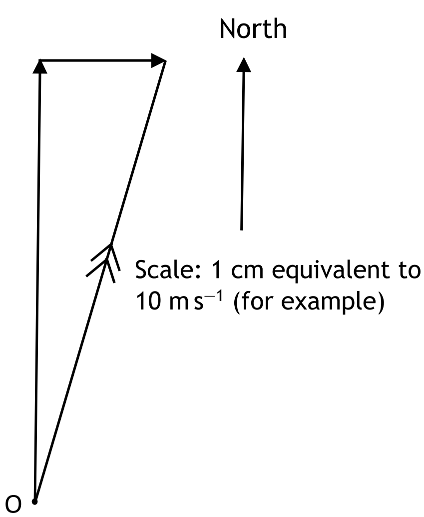
$v=155\,\text{m s}^{-1}$ 1

Accept 150, 155·2, 155·24

</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>

Scale diagram

θ=15±2°



</td><td>2</td><td>

Trigonometry

$\tan\theta=\frac{40}{150}$ 1

$\theta=15°$ 1

Accept 10, 14·9, 14·93

Bearing 015

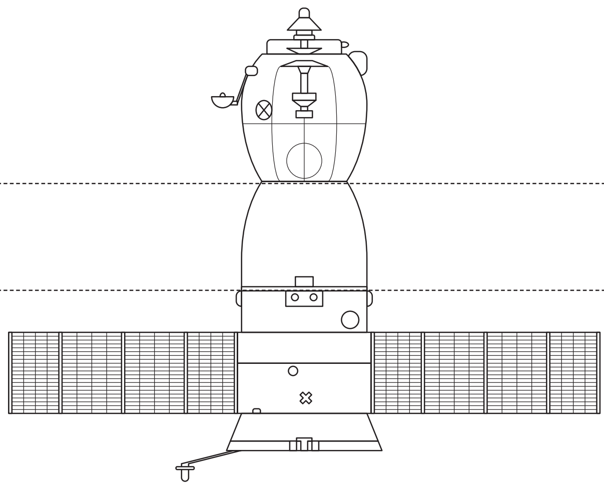
15° E of N

</td></tr>
</table>

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**	

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

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**

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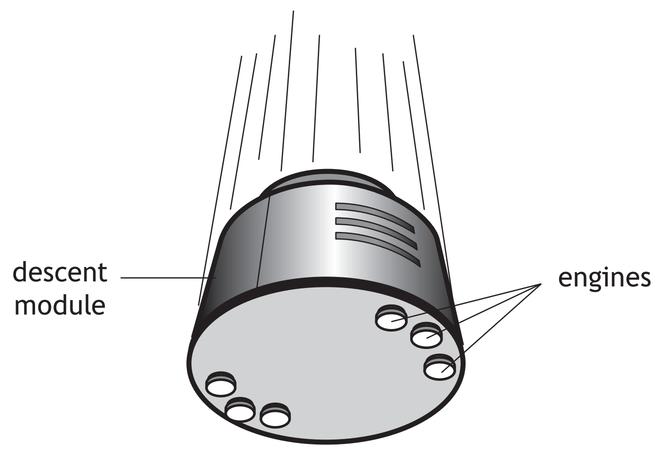
2. (c) (continued)

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 $F = ma$ 1 $1430 = (1300 + 2950 + 2900) \times a$ 1 $a = 0 \cdot 2\,\text{m s}^{-2}$ 1	**4**	
	(b)		Force of friction is created on the surface of the modules 1 causes heat to be produced 1	**2**	
	(c)	(i)	Upward force is increased (by parachutes) 1 producing an unbalanced force upwards 1	**2**	
		(ii)	$E_w = Fd$ 1 $80\,000 = F \times 5$ 1 $F = 16\,000\,\text{N}$ 1	**3**	Accept 20 000, 16 000·0, 16 000·00
	(d)	(i)	$T = \dfrac{2\pi R}{v}$ $T = \dfrac{2 \times \pi \times (6 \cdot 4 \times 10^6 + 3 \cdot 30 \times 10^5)}{7 \cdot 7 \times 10^3}$ 1,1 $T = 5500\,\text{s}$ 1	**3**	1 mark for substitution of radius plus altitude Accept 5000, 5490, 5492
		(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 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	**2**	

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**

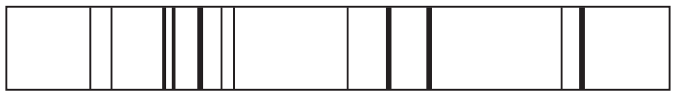
Space for working and answer

* S 8 5 7 7 5 0 1 1 3 *

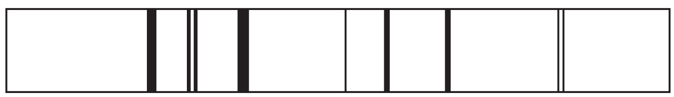
3. (continued) MARKS DO NOT WRITE IN THIS MARGIN

(c) State how the frequency of microwave radiation compares to the frequency of infrared radiation. 1

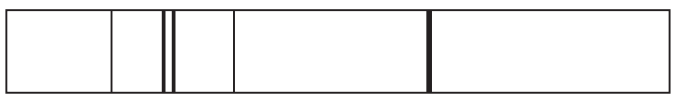
(d) A line spectrum from a nebula is shown below.



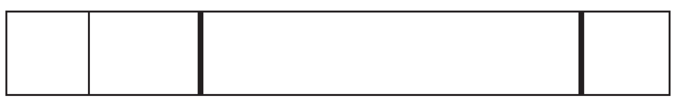
spectral lines from gases in the nebula



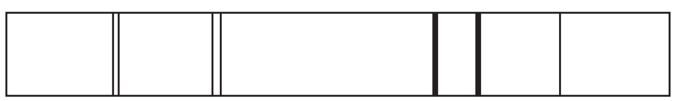
nitrogen



helium



hydrogen



krypton

Identify which of these elements are present in the nebula. 2

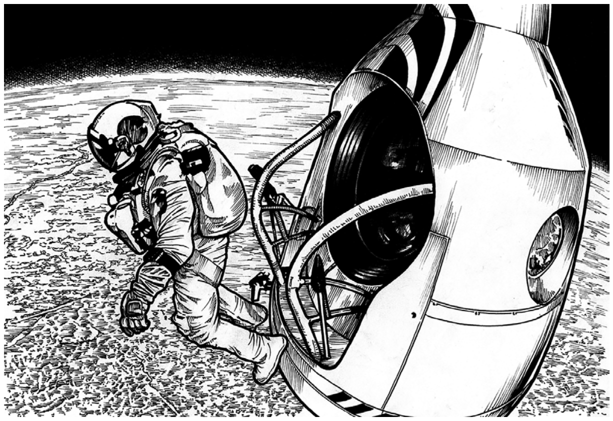
Question			Expected response	Max mark	Additional guidance
3.	(a)		Milky Way	**1**	
	(b)		$d = vt$ 1 $d = 30\,000 \times 3 \times 10^8 \times (365 \cdot 25 \times 24 \times 60 \times 60)$ 1,1 $d = 2 \cdot 8 \times 10^{20}$ m	**3**	**'Show' question** Accept 365, 365·24 If final answer not stated max 2 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.

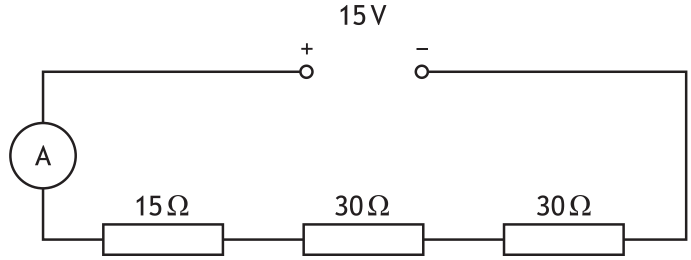
He also became the first human to fall at speeds higher than the speed of sound in air.



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

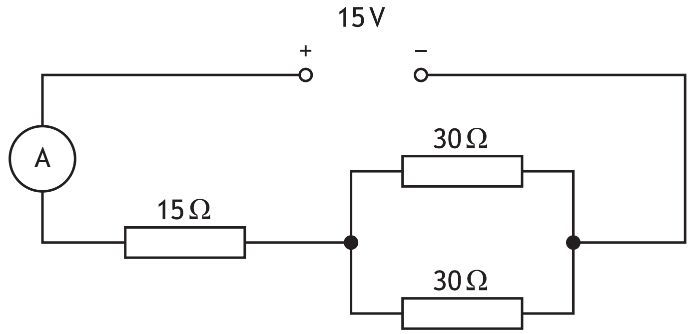
(iii) Calculate the power dissipated in the 15 Ω resistor. **3**

Space for working and answer

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**

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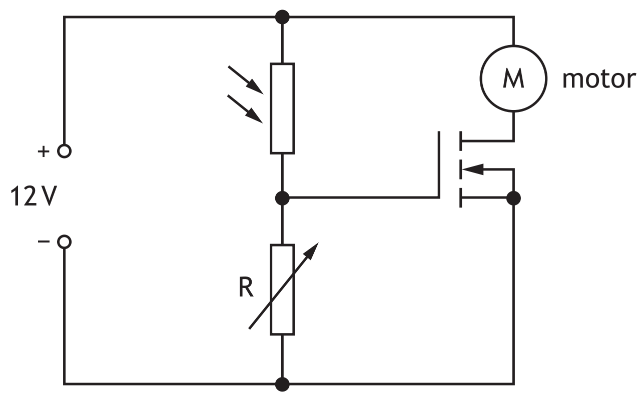
Question			Expected response	Max mark	Additional guidance
5.	(a)	(i)	$R_T = 75\ \Omega$	1	
		(ii)	$V = IR$ 1 $15 = I \times 75$ 1 $I = 0 \cdot 20$ A 1	3	Or consistent with (a)(i) Accept 0·2, 0·200, 0·2000
		(iii)	$P = I^2 R$ 1 $P = 0 \cdot 20^2 \times 15$ 1 $P = 0 \cdot 60$ W 1	3	Or consistent with (a)(ii) Accept 0·6, 0·600, 0·6000
	(b)		(The power dissipated is) greater (than that in (a)(iii)) 1 The total resistance of the circuit is now less 1 The current in the circuit is now greater 1	3	**‘Must justify’ question**

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.

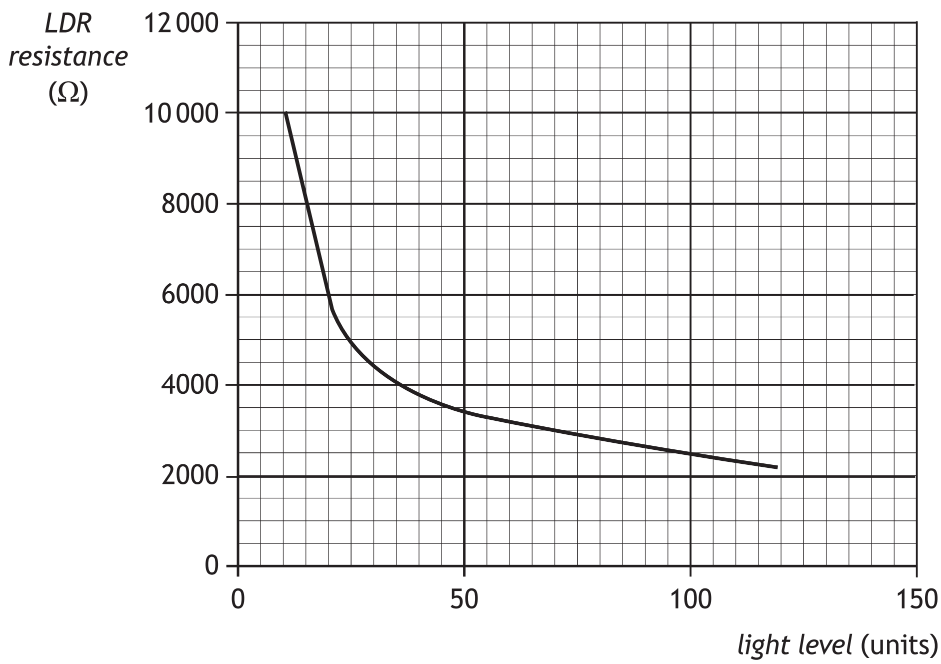
(i) Explain how this circuit works to close the blind. **3**

(ii) What is the purpose of the variable resistor R? **1**

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

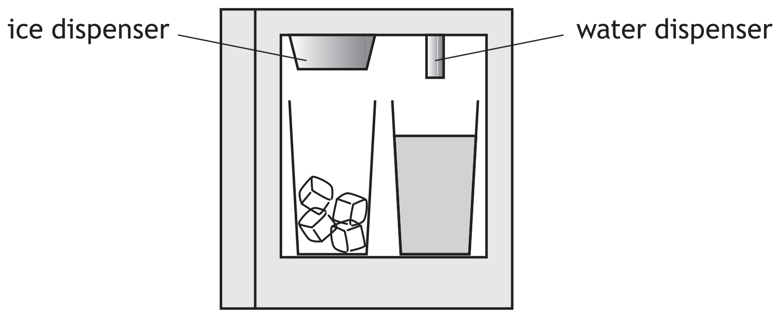
(iii) State whether or not the blinds will close when the light level is 70 units.

Justify your answer. **2**

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)	$V_2 = \left(\dfrac{R_2}{R_1 + R_2}\right)V_s$ 1 $V_2 = \left(\dfrac{600}{600 + 3000}\right)\times 12$ 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 $6·27 \times 10^3$ 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

* S 8 5 7 7 5 0 1 2 0 *

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 $0\cdot100\,kg$ of ice from $0\cdot100\,kg$ of water at $15\cdot0\,°C$. **4**

Space for working and answer

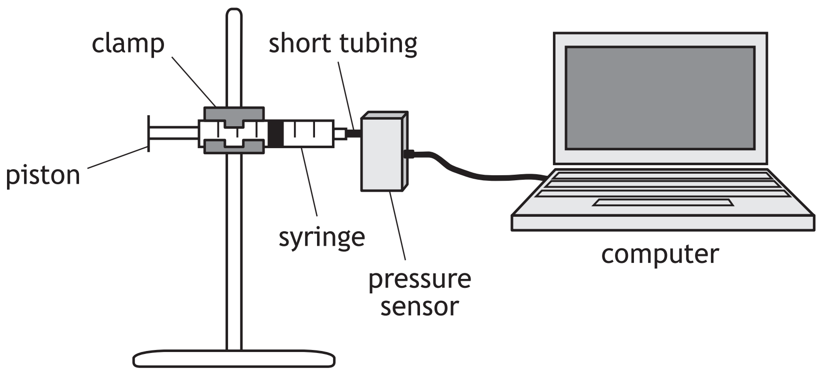
(ii) Explain why the actual time taken to make the ice will be longer than the time calculated in part (c) (i). **2**

* 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 $E_h = 4180 \times 0 \cdot 100 \times (15 \cdot 0 - 0)$ 1 $E_h = 6270$ J	2	**'Show' question**
	(b)		$E_h = ml$ 1 $E_h = 0 \cdot 100 \times 3 \cdot 34 \times 10^5$ 1 $E_h = 3 \cdot 34 \times 10^4$ J 1	3	Accept 3·3, 3·340, 3·3400
	(c)	(i)	$E_h = 6270 + 3 \cdot 34 \times 10^4$ (J) 1 $P = \frac{E_h}{t}$ 1 $115 = \frac{(6270 + 3 \cdot 34 \times 10^4)}{t}$ 1 $t = 345$ s 1	4	Or consistent with (b) Accept 340, 345·0, 345·00
		(ii)	Heat will be taken in from the surroundings 1 so the system will have additional heat to remove 1	2	

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**

MARKS | DO NOT WRITE IN THIS MARGIN

8. (continued)

(b) Calculate the pressure of the gas in the syringe when its volume is $8{\cdot}0\,cm^3$. **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**

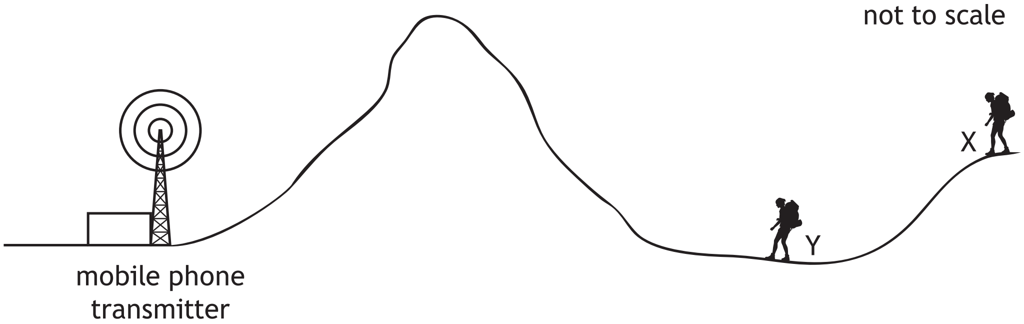
Space for working and answer

Back to Table

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**

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Back to Table

Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	$3{\cdot}00\times10^{8}\ \mathrm{m\,s^{-1}}$	1	Accept 3, 3·0
		(ii)	$d = vt$ 1 $d = 3\cdot00\times10^{8}\times0\cdot0047$ 1 $d = 1\cdot4\times10^{6}\ \mathrm{m}$ 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 $\lambda = 0\cdot185\ \mathrm{m}$ 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.'

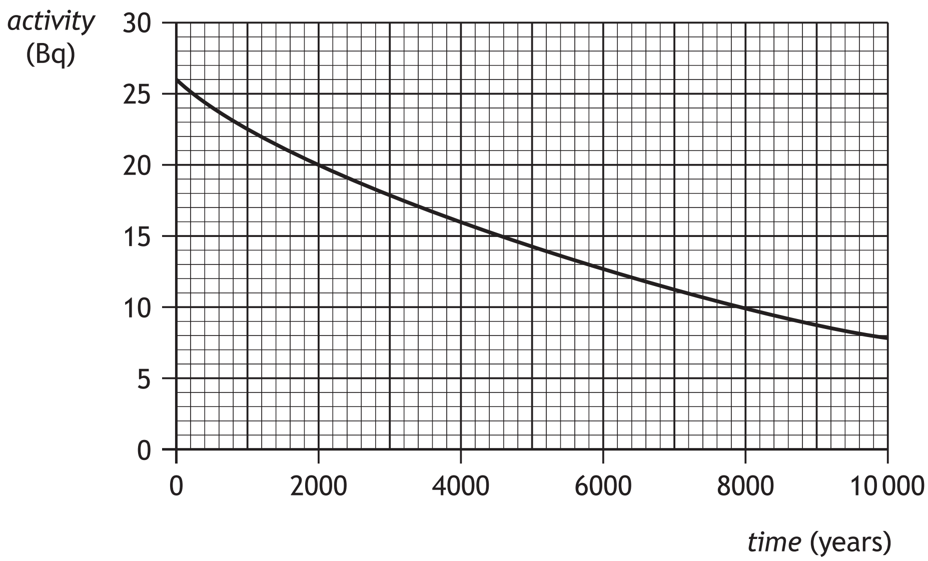
Using your knowledge of physics, comment on the similarities and/or differences between electromagnetic waves and the ripples on a pond. **3**

S857750127

MARKS DO NOT WRITE IN THIS MARGIN

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

S857750128

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**

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)		$D=\dfrac{E}{m}$ 1 $50\times10^{-6}=\dfrac{E}{0{\cdot}10}$ 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.

X857502

A/HTP

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

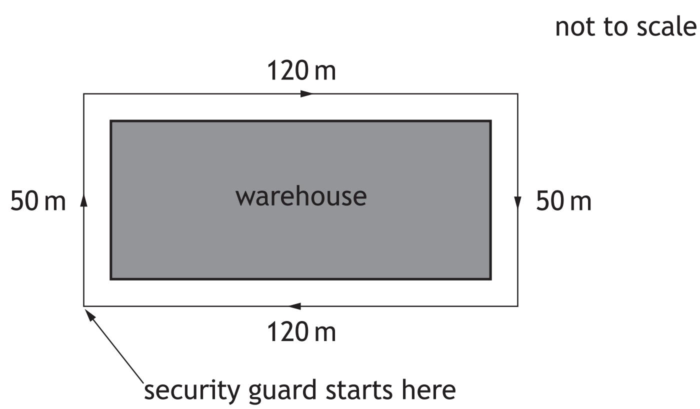
SECTION 1

Attempt ALL questions

1. 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.

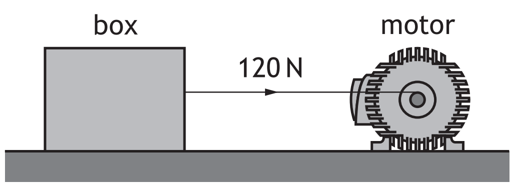
B There is only a horizontal force acting on the ball.

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 $14\,N\,kg^{-1}$.

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

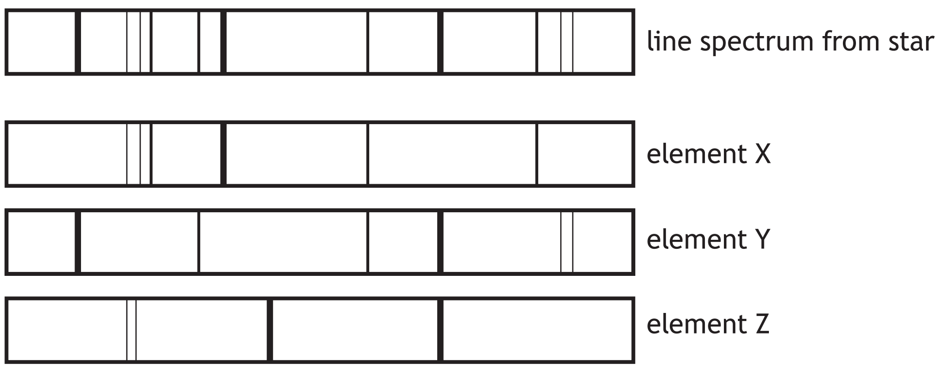
C $3{\cdot}4 \times 10^{15}$ m

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

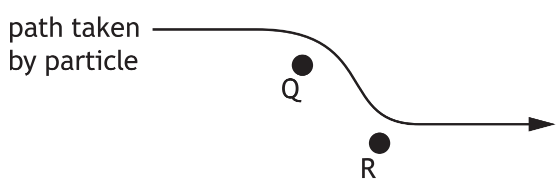
D I and III only

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.

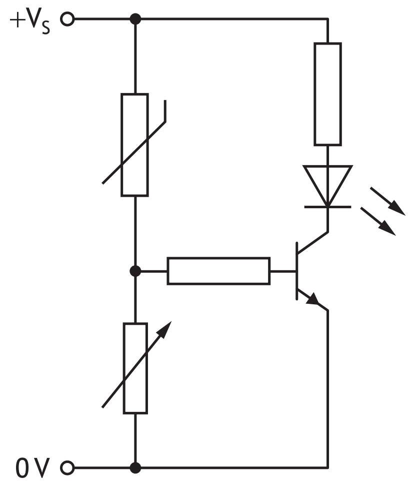


Which row in the table identifies the charge on the particle, the charge on Q and the charge on R?

	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.

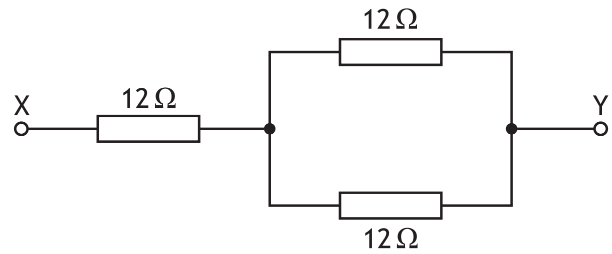
The temperature of the thermistor is now increased.

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

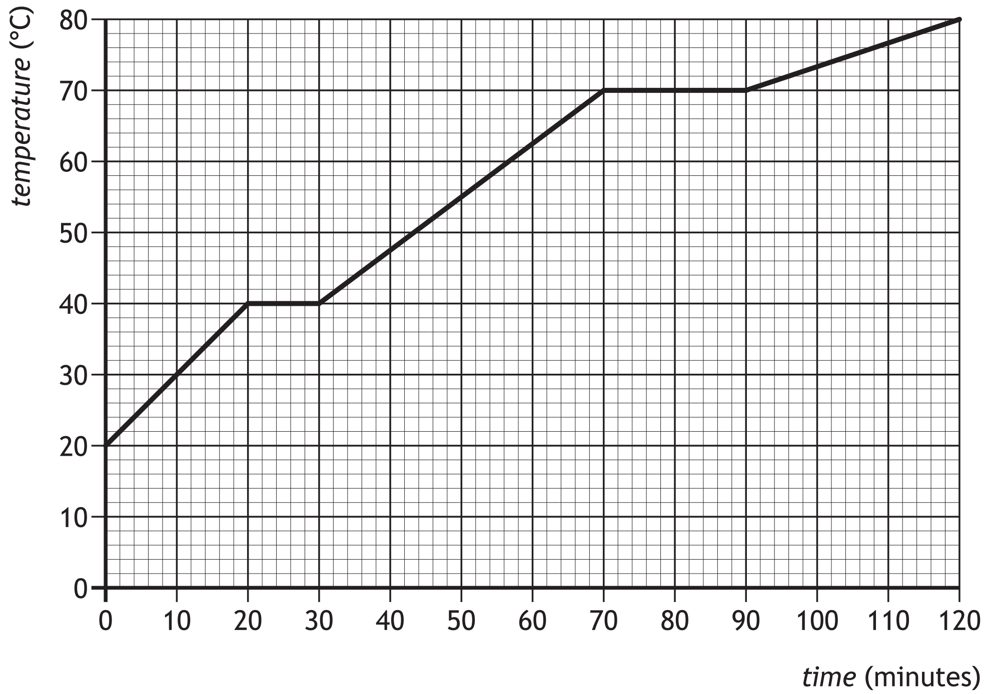
E 576 W.

[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 $2{\cdot}0\,\mathrm{m}^2$.

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

Back to Table

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 $1{\cdot}02 \times 10^3\ \text{kg m}^{-3}$.

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

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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

* 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 *

DO NOT WRITE IN THIS MARGIN

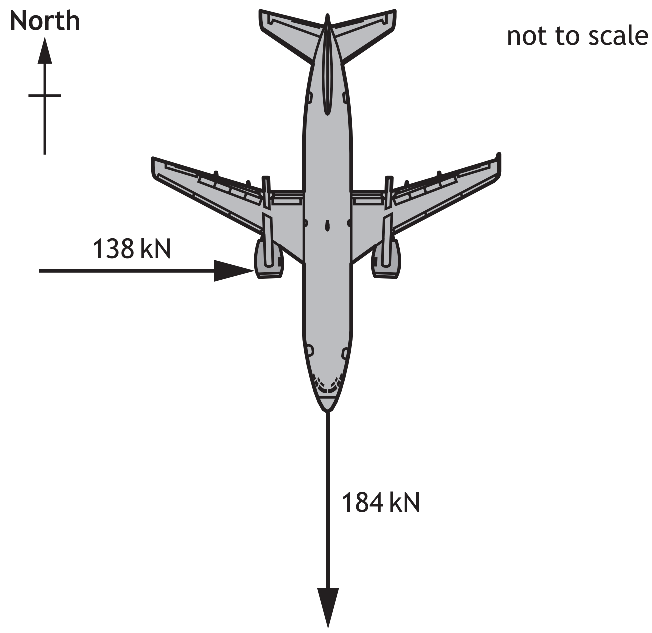
SECTION 2 — 110 marks

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

MARKS | DO NOT WRITE IN THIS MARGIN

1. (a) (continued)

(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**

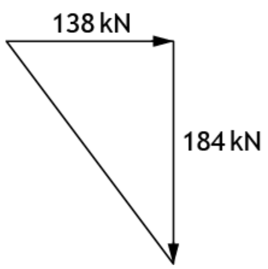
Space for working and answer

(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**

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

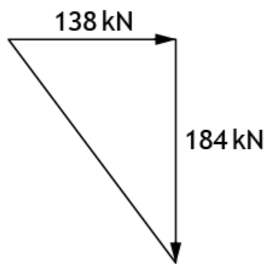
Section 2

<table>
<tr><th colspan="3">Question</th><th>Expected response</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>1.</td><td>(a)</td><td>(i)
(A)</td><td>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)</td><td>2</td><td>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.</td></tr>
</table>

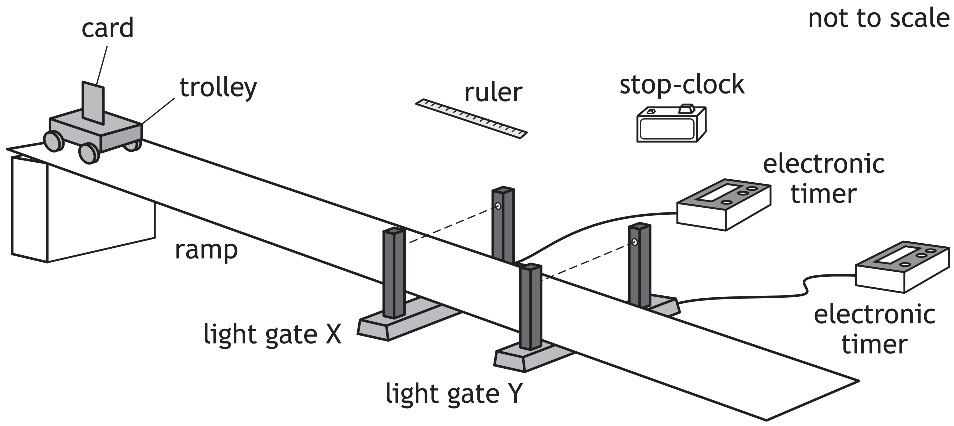
Question			Expected response	Max mark	Additional guidance
1.	(a)	(i) (B)	**Using scale diagram:**  Angles correct **(1)** direction = 143 **(1)** (allow ±2° tolerance) **Using trigonometry:** $tan\,\theta = \frac{184}{138}$ **(1)** $(\theta = 53{\cdot}1°)$ direction = 143 **(1)**	**2**	Or use of the 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 $0{\cdot}32\,\mathrm{m\,s^{-1}}$.

(i) State the **additional** measurement made by the student to determine the instantaneous speed of the trolley at light gate X. **1**

X857750110

2. (a) (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(ii) Show that the instantaneous speed of the trolley at light gate Y is $0{\cdot}46\,m\,s^{-1}$. **2**

Space for working and answer

(iii) Determine the acceleration of the trolley down the ramp. **3**

Space for working and answer

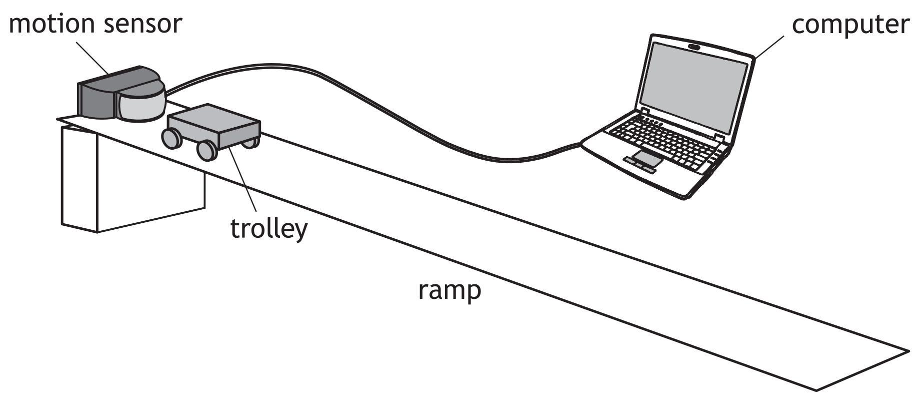
[Turn over

X857750111

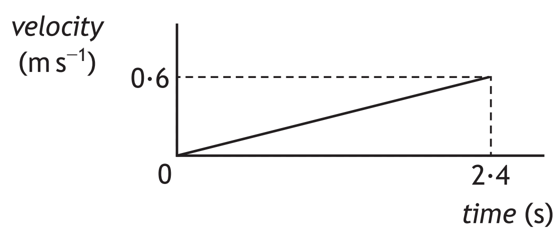
2. (continued)

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**

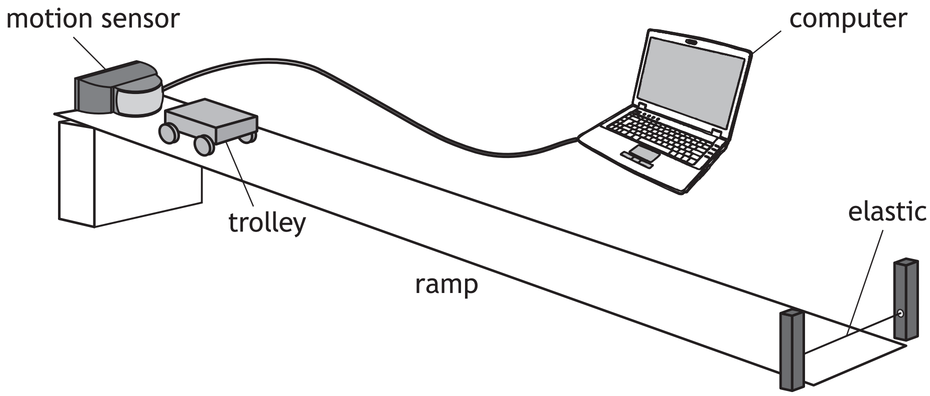
Space for working and answer

Back to Table

2. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

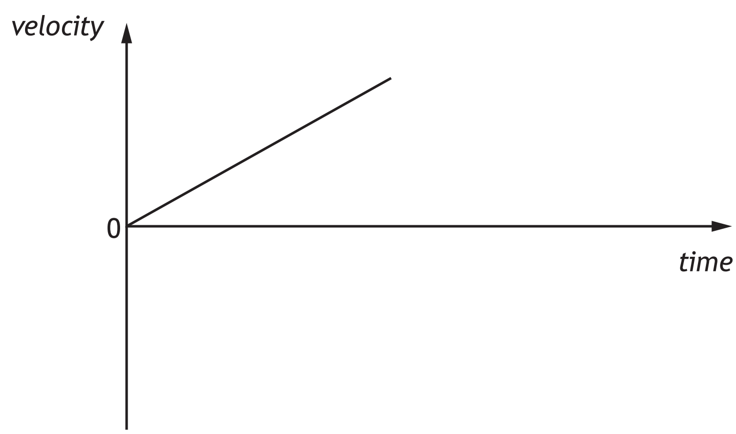
(c) In a further experiment the second student places a piece of elastic across the bottom of the ramp as shown.



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**

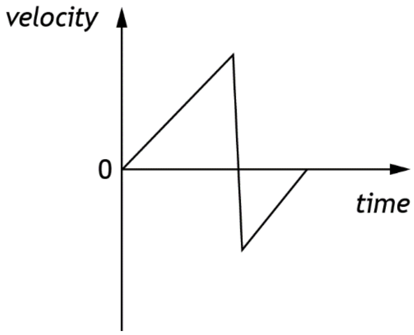
Numerical values are not required on either axis.



(An additional diagram, if required, can be found on *page 43*.)

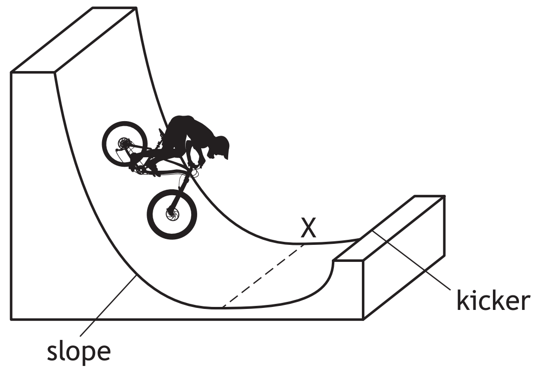
[Turn over

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)	$v = \dfrac{length\ of\ card}{time\ for\ card\ to\ cut\ beam}$ **(1)** $v = \dfrac{0{\cdot}045}{0{\cdot}098}$ **(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: $v = \dfrac{d}{t}$ or $v = \dfrac{s}{t}$ or $\bar{v} = \dfrac{d}{t}$ or $\bar{v} = \dfrac{s}{t}$ if substitutions are correct.
		(iii)	$a = \dfrac{v - u}{t}$ **(1)** $a = \dfrac{0{\cdot}46 - 0{\cdot}32}{0{\cdot}56}$ **(1)** $a = 0{\cdot}25\ \text{m s}^{-2}$ **(1)**	**3**	Accept: $a = \dfrac{\Delta v}{t}$ or $v = u + at$ Do not accept: $a = \dfrac{v}{t}$ 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)** $= \dfrac{1}{2} \times 2{\cdot}4 \times 0{\cdot}60$ **(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 $8{\cdot}0\,m\,s^{-1}$.

(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**

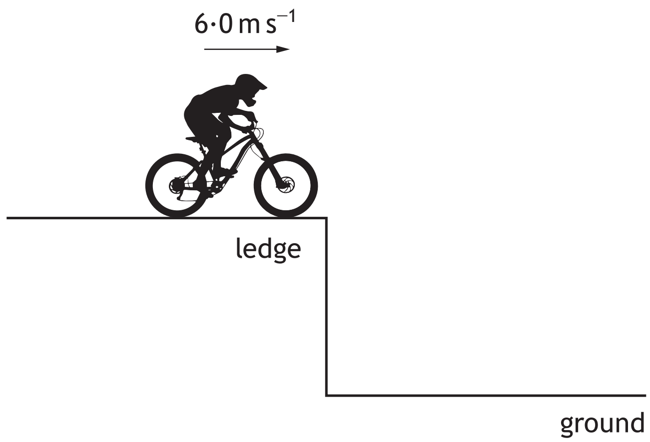
* X 8 5 7 7 5 0 1 1 4 *

Back to Table

3. (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(c) During another part of the competition, the cyclist and bike travel horizontally at $6{\cdot}0\,m\,s^{-1}$ 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 $0{\cdot}40\,s$ 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

Back to Table

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)	<u>Energy</u> 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)	$a = \dfrac{v-u}{t}$ **(1)** $9{\cdot}8 = \dfrac{v-0}{0{\cdot}40}$ **(1)** $v = 3{\cdot}9$ m s^{-1} **(1)**	**3**	Accept: $a = \dfrac{\Delta v}{t}$ OR $v = u + at$ Do not accept a response starting with $a = \dfrac{v}{t}$ 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 AU = $1{\cdot}50 \times 10^{11}$ m.

Mars orbits the Sun at an average distance of 1·52 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)	$d = (1 \cdot 50 \times 10^{11} \times 1 \cdot 52)$ $= 2 \cdot 28 \times 10^{11}$ (m)	1	Unit not required but if stated must be correct. Accept 2-5 sig figs: $2 \cdot 3 \times 10^{11}$ $2 \cdot 280 \times 10^{11}$ $2 \cdot 2800 \times 10^{11}$
		(ii)	$d = vt$ (1) $2 \cdot 28 \times 10^{11} = 3 \cdot 0 \times 10^{8} \times t$ (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.'

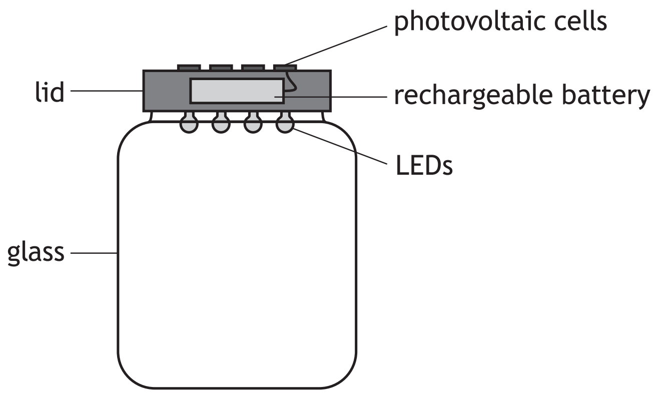
Using your knowledge of physics, comment on the statement made by the student. **3**

X857750118

MARKS | DO NOT WRITE IN THIS MARGIN

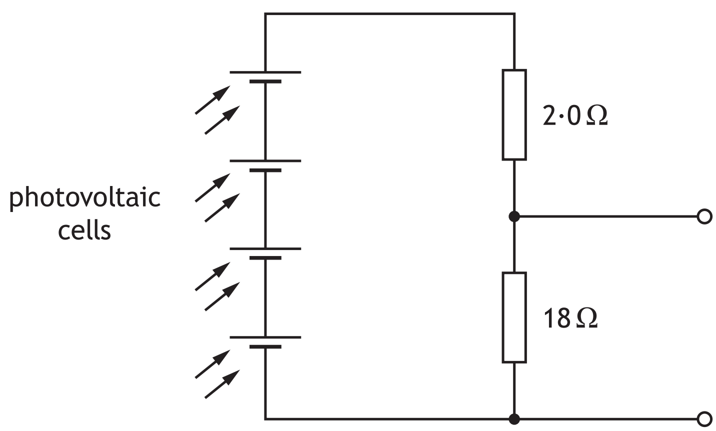
6. A solar jar is designed to collect energy from the Sun during the day and release this energy as light at night.

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

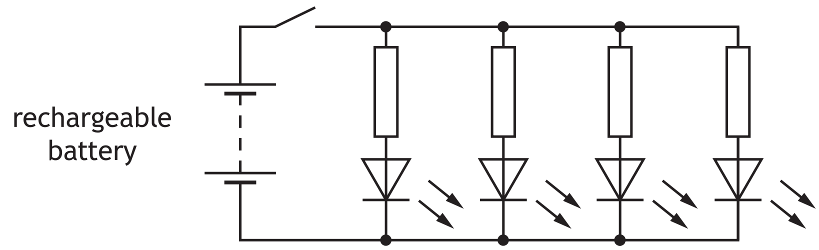
[Turn over

* X 8 5 7 7 5 0 1 1 9 *

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

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

X857750121

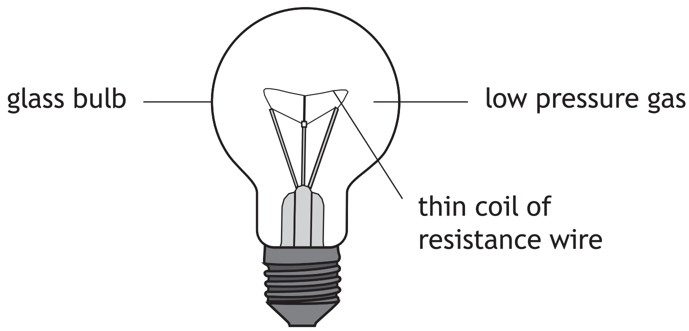
Question			Expected response	Max mark	Additional guidance
6.	(a)		$V_2 = \frac{R_2}{R_1 + R_2} \times V_s$ **(1)** $V_2 = \frac{18}{18 + 2 \cdot 0} \times 4 \cdot 0$ **(1)** $V_2 = 3 \cdot 6$ V **(1)**	3	**Method 2:** $V = IR$ $4 \cdot 0 = I \times (18 + 2 \cdot 0)$ $(I = 0 \cdot 2$ A$)$ $V = IR$ $= 0 \cdot 2 \times 18$ $= 3 \cdot 6$ 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) $\frac{V_1}{4 \cdot 0} = \frac{18}{20}$ (1) $V_1 = 3 \cdot 6$ 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

Back to Table

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.



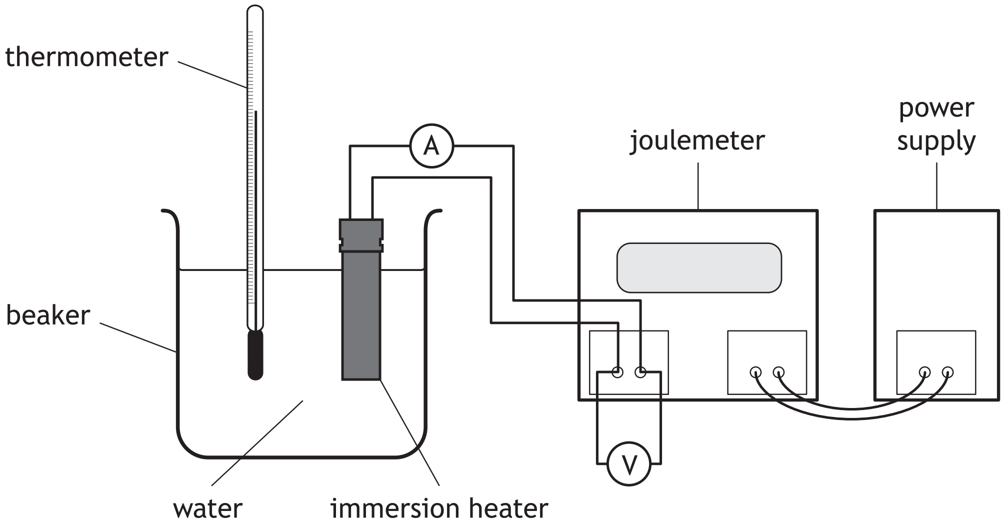
Using your knowledge of physics, comment on the suitability of this design as a light source. **3**

X857750122

Back to Table

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

X857750124

8. (a) (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(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**

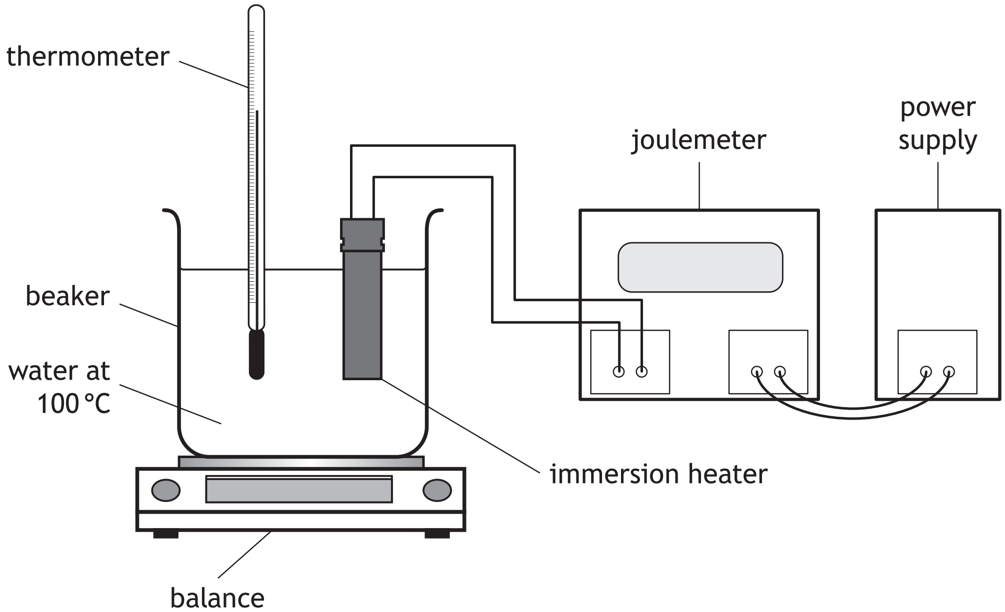
Space for working and answer

[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**

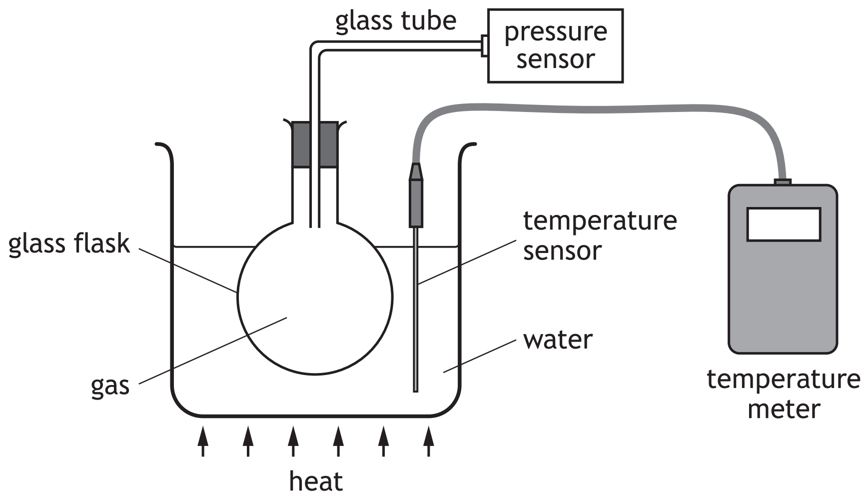
Your description must include:

- 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)** $c = 5\,400$ J kg^{-1} °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 J kg^{-1} °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)** $= 4{\cdot}0 \times 12$ $= 48$ (W) $P = \frac{E}{t}$ (1) $48 = \frac{21600}{t}$ (1) $t = 450$ 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) $t = 450$ 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

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

<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>(i)</td><td>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 $\frac{T}{p}$:
$\frac{293}{101\times10^3} = 0\cdot00290$
$\frac{313}{107\times10^3} = 0\cdot00293$
$\frac{333}{116\times10^3} = 0\cdot00287$
$\frac{353}{122\times10^3} = 0\cdot00289$

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)</td><td>3</td><td>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)</td></tr>
</table>

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

MARKS | DO NOT WRITE IN THIS MARGIN

10. A student connects a mobile phone to a speaker wirelessly using a microwave signal.

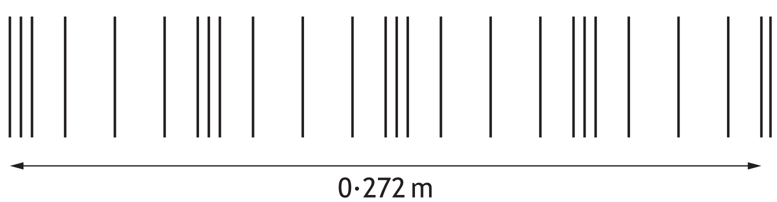
(a) The time taken for the microwave signal to travel from the mobile phone to the speaker is $2{\cdot}1 \times 10^{-8}$ s.

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**

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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

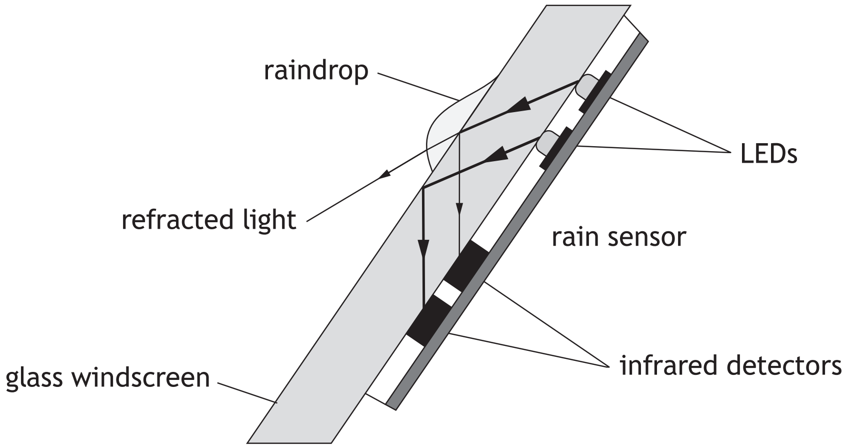
[Turn over

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

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.

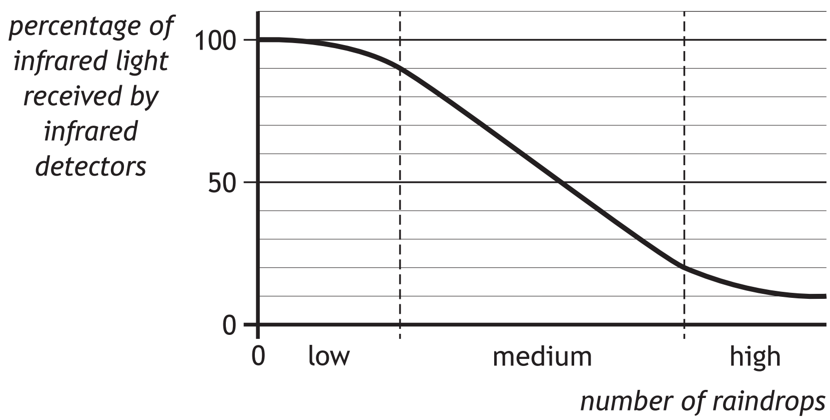
(a) State a suitable detector of infrared radiation for this rain sensor. **1**

Back to Table

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

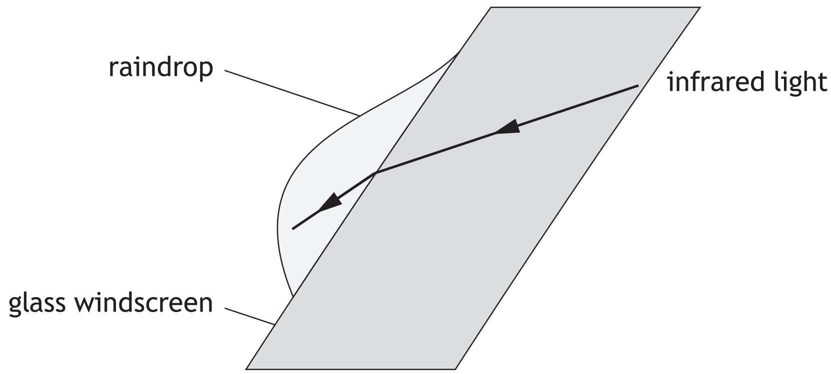
* X 8 5 7 7 5 0 1 3 3 *

Back to Table

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.

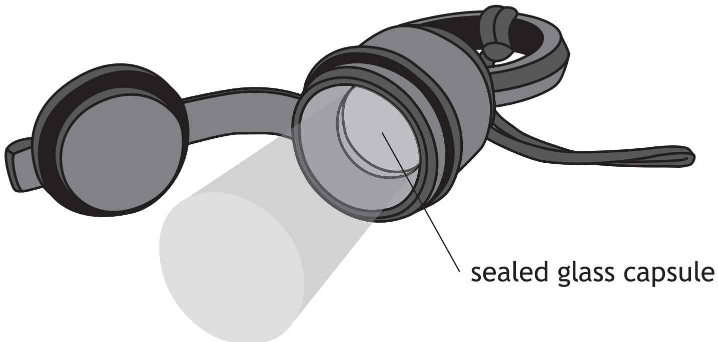
You **must** justify your answer. **2**

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)** $f = \frac{N}{t}$ **(1)** $f = \frac{54}{60}$ **(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. $T = \frac{60}{54} (= 1{\cdot}11)$ **(1)** $f = \frac{1}{T}$ **(1)** $f = \frac{1}{1{\cdot}11}$ **(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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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

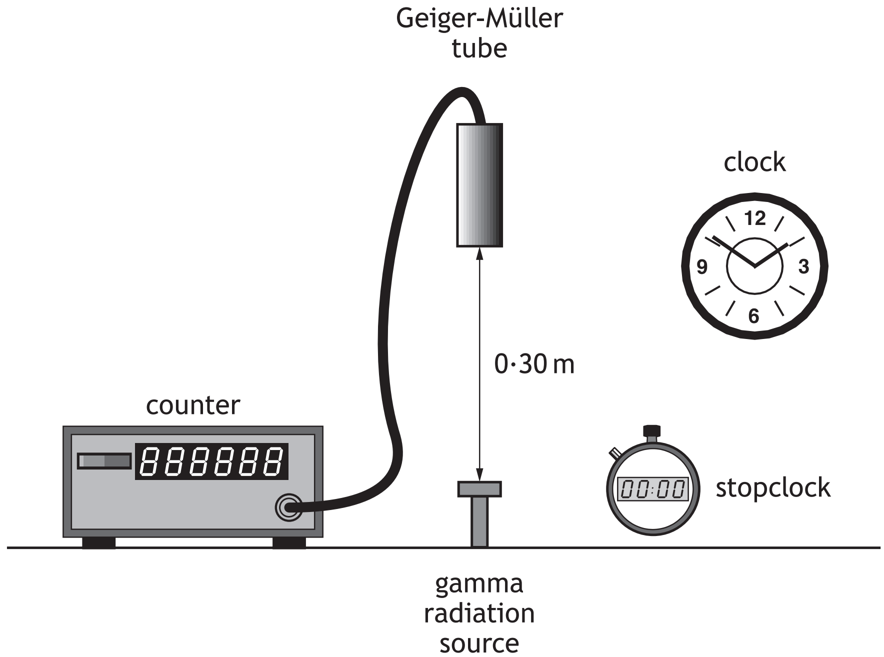
(ii) Calculate the equivalent dose received by the worker. **3**

Space for working and answer

[Turn over

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)** $E = 0 \cdot 034$ 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)** $= 4 \cdot 0 \times 10^{-4}$ 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

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]