Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel Level 1/Level 2 GCSE (9–1)

Thursday 25th May 2023

Morning (Time: 1 hour 45 minutes)

Paper reference **1PH0/1F**

Physics

PAPER 1

Foundation Tier

You must have:
Calculator, ruler, Equation Booklet (enclosed)

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 100.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.
- A list of equations is included at the end of this exam paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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P 7 2 5 7 2 A 0 1 3 2

Pearson

Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 This question is about waves in the electromagnetic (e-m) spectrum.

(a) (i) Figure 1 shows some types of radiation that form part of the e-m spectrum and some uses of e-m radiation.

Draw **one** straight line from each type of e-m radiation to its use.

One line has been drawn for you.

(3)

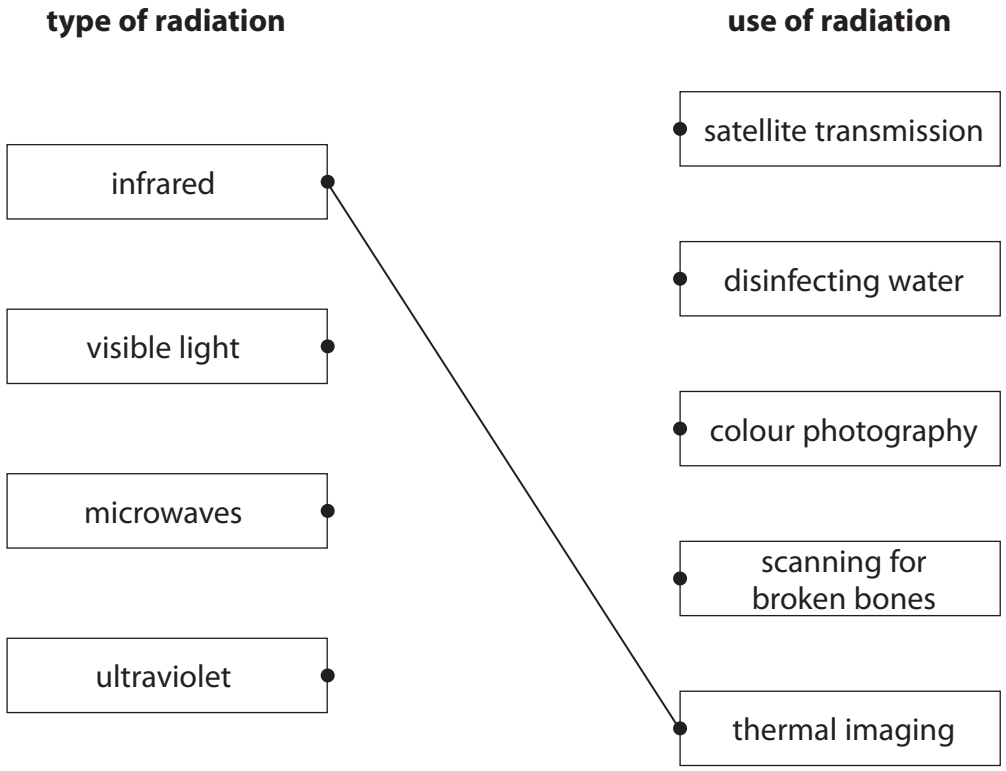

Figure 1

(ii) Which of these waves has the highest frequency?

(1)

☒ **A** infrared

☒ **B** microwaves

☒ **C** ultraviolet

☒ **D** visible light

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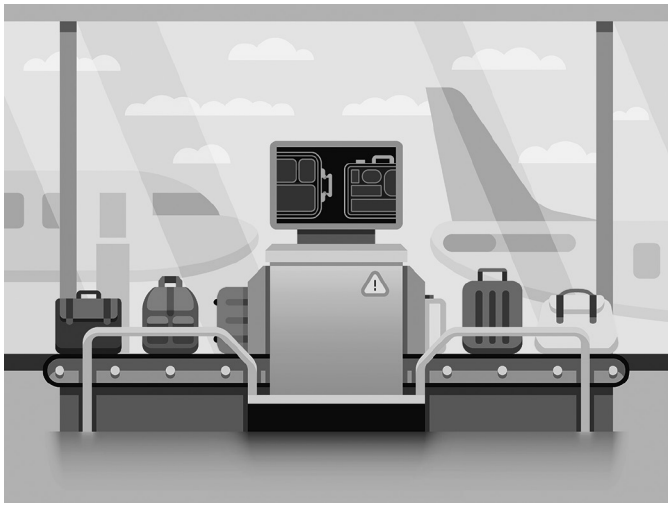
(b) X-rays are also part of the e-m spectrum.

Figure 2 shows an airport security scanner using X-rays to scan passengers' bags.



(Source: © Net Vector / Shutterstock)

Figure 2

(i) Explain why X-rays are used to scan passengers' bags.

(2)

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(ii) Explain why passengers are **not** scanned with X-rays.

(2)

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(Total for Question 1 = 8 marks)

2 (a) Figure 3 shows a ray of light striking a mirror.

The angle of incidence is 30° and the ray of light is reflected.

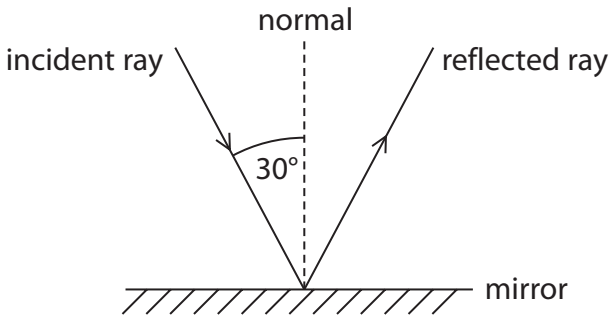

Figure 3

The angle of reflection is the angle between

(1)

- ☒ **A** the mirror and the incident ray
- ☒ **B** the mirror and the normal
- ☒ **C** the reflected ray and the incident ray
- ☒ **D** the reflected ray and the normal

(b) Figure 4 shows two lenses, P and Q, arranged to form a simple telescope.

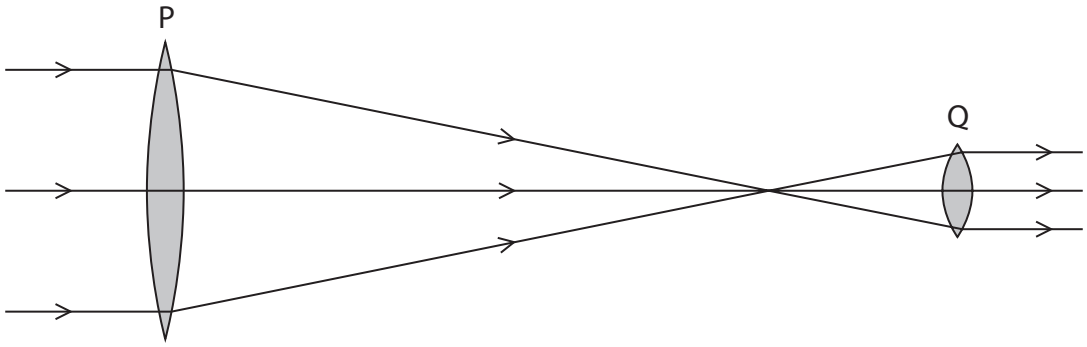

Figure 4

(i) State **one** use for a telescope.

(1)

.....

.....

(ii) Which of these describes the lenses?

(1)

- ☒ **A** P is converging, Q is diverging
- ☒ **B** P is diverging, Q is converging
- ☒ **C** P and Q are both converging
- ☒ **D** P and Q are both diverging

(iii) The focal length of lens Q is 0.14 m.

Calculate the power of the lens.

(2)

Use the equation

$$\text{power} = \frac{1}{\text{focal length in m}}$$

power of lens = ... dioptre

(c) A student is in a laboratory that has windows.

The student is given a converging lens, and a sheet of paper.

Describe how the student can produce an image of the window frame on the sheet of paper.

(2)

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(Total for Question 2 = 7 marks)

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3 (a) The graph in Figure 5 shows how the velocity of a car changes with time.

The car starts from rest and travels along a level, straight road for 50 s.

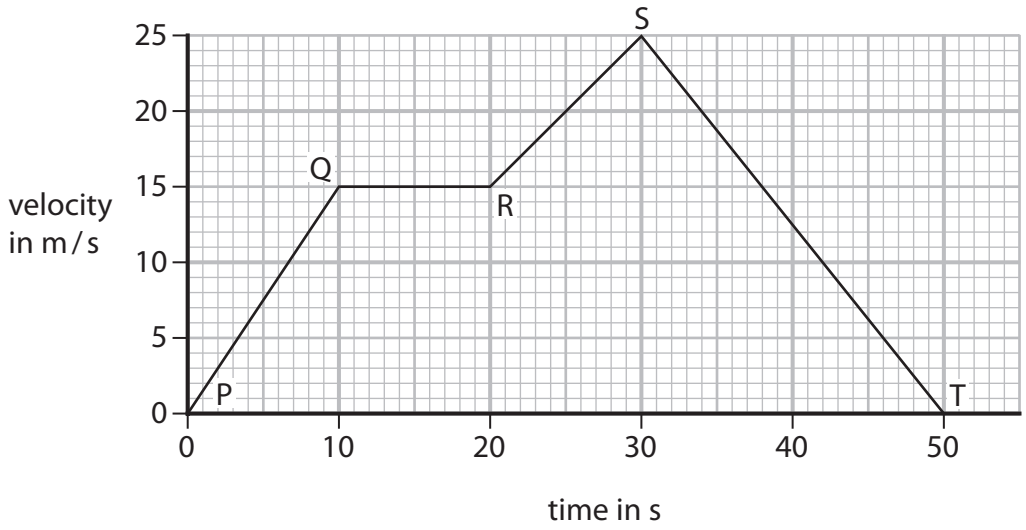

Figure 5

(i) Which part of the graph shows when the car has constant velocity?

(1)

☒ **A** PQ

☒ **B** QR

☒ **C** RS

☒ **D** ST

(ii) Which part of the graph shows when the car has the greatest acceleration?

(1)

☒ **A** PQ

☒ **B** QR

☒ **C** RS

☒ **D** ST

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(iii) Calculate the acceleration of the car in the first 10 s shown on the graph.

(2)

Use the equation

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time}}$$

acceleration = ... m / s^2

(iv) Calculate the distance the car travels in part QR shown on the velocity / time graph in Figure 5.

(3)

distance = ... m

(b) A different car has a mass of 1200 kg.

Calculate the force needed to give this car an acceleration of 2.4 m / s^2.

(2)

Use the equation

$$F = m \times a$$

force = ... N

(Total for Question 3 = 9 marks)

4 An atom has a central nucleus containing neutrons and protons.

Electrons orbit the nucleus.

(a) (i) Which row of the table gives the relative mass and charge of a proton?

(1)

		relative mass	charge
☒	**A**	0	+1
☒	**B**	0	–1
☒	**C**	1	+1
☒	**D**	1	–1

(ii) An atom has a radius of 1.0×10^{-10} m.

A nucleus has a radius of 1.0×10^{-15} m.

Calculate the ratio of the radius of the atom to the radius of the nucleus.

(2)

ratio of radius of atom to radius of nucleus = ...

(iii) Explain why an atom has no charge overall.

(2)

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(b) One isotope of carbon is carbon-14.

$$^{14}_{6}C$$

(i) State the number of protons in one atom of carbon-14.

(1)

number of protons = ...

(ii) State the number of neutrons in one atom of carbon-14.

(1)

number of neutrons = ...

(iii) Figure 6 shows a graph for the decay of the radioactive isotope carbon-14.

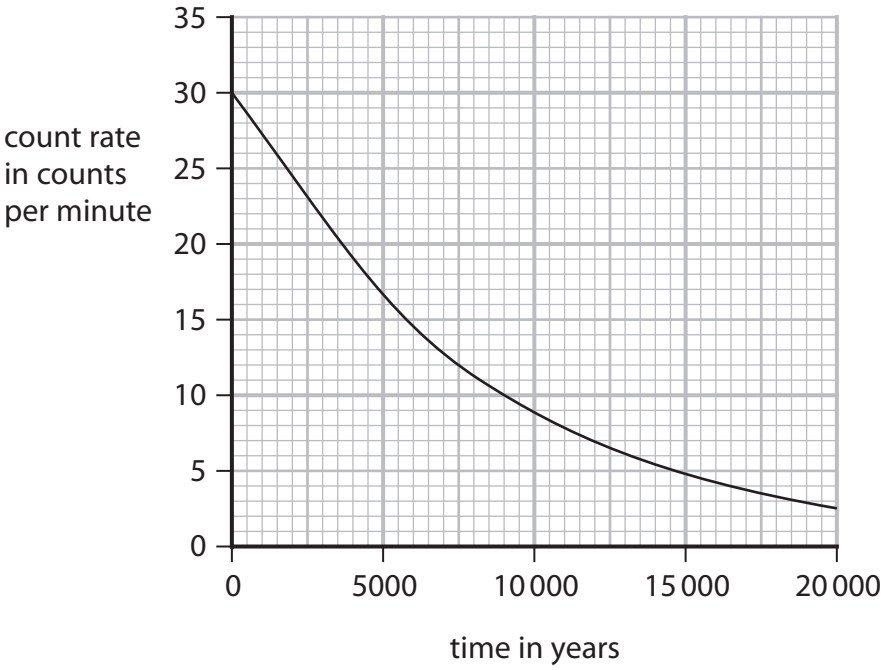

Figure 6

Use the graph to estimate the half-life of carbon-14.

(2)

half-life = ... years

(Total for Question 4 = 9 marks)

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5 (a) Figure 7 shows a wave on the surface of water.

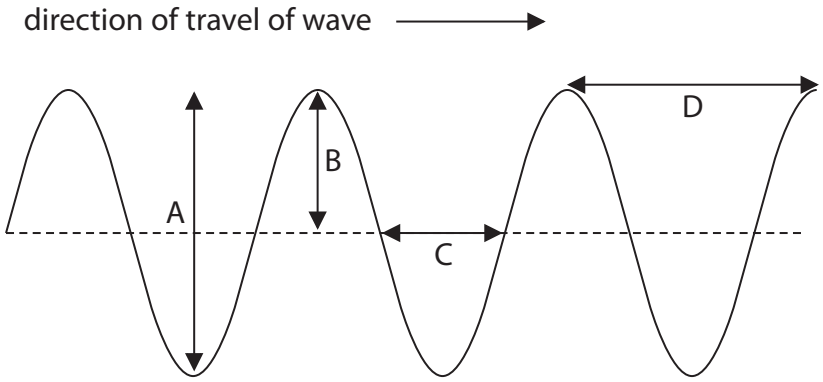

Figure 7

(i) Which of the arrowed lines shows the amplitude of the wave?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(ii) Explain why the wave shown in Figure 7 is a transverse wave.

(2)

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(b) Figure 8 shows a ripple tank.

A screen is placed below the ripple tank.

The wave pattern produced by the ripples can be seen on the screen.

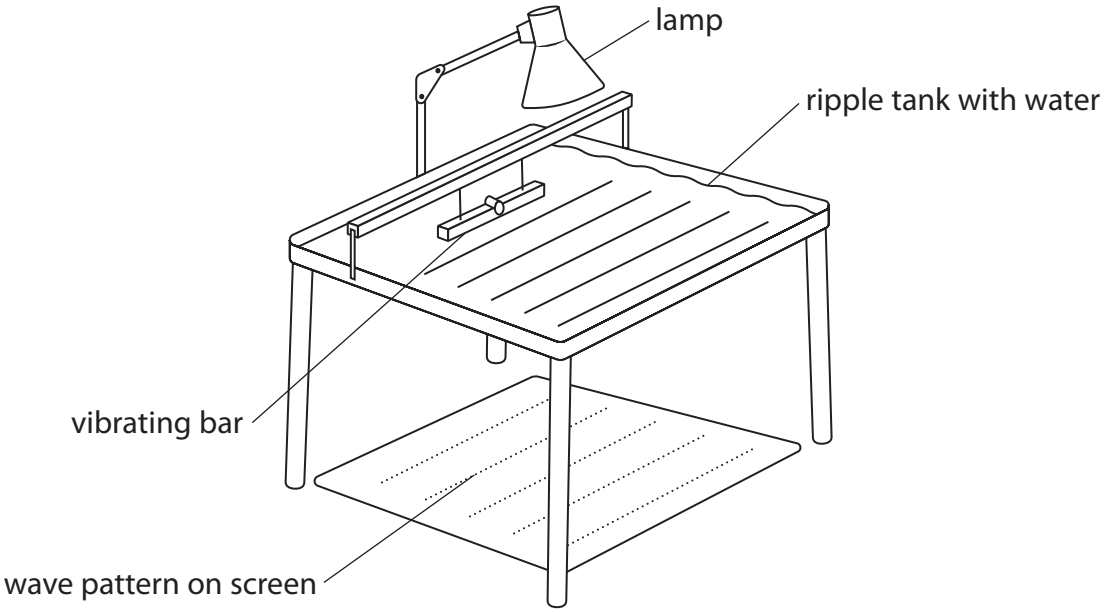

Figure 8

A student has a stop clock and a ruler.

(i) Describe how the student could measure the frequency of the ripples.

(2)

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(ii) Describe how the student could measure the wavelength of the ripples.

(2)

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(c) In a swimming pool, a wave is produced with a wavelength of 4.0 m and a velocity of 0.8 m / s.

Calculate the frequency of the wave.

State the unit of frequency.

(3)

Use the equation

$$v = f \times \lambda$$

frequency of wave ..... unit .....

(Total for Question 5 = 10 marks)

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6 (a) Figure 9 shows a metal cube filled with hot water.

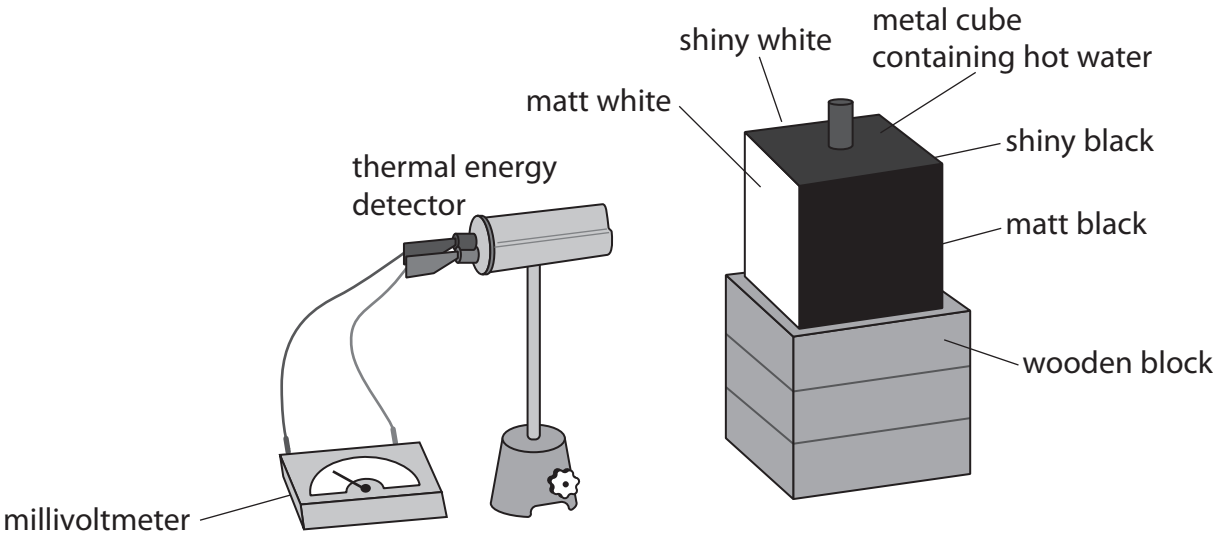

Figure 9

Four sides of the cube have different surfaces, as shown in Figure 9.

The four surfaces are at the same temperature.

The thermal energy radiated by each side of the box is measured using a thermal energy detector connected to a millivoltmeter.

The detector is moved to get a reading of the thermal energy emitted from each side of the box.

Figure 10 shows the table of results.

type of surface	millivoltmeter reading in mV
matt white	32
shiny white	20
shiny black	
matt black	55

Figure 10

(i) Suggest a possible millivoltmeter reading for the shiny black surface.

(1)

..... mV

(ii) State what must be kept the same to take the measurement for each surface.

(1)

.....

.....

(iii) Suggest why the cube is placed on a block of wood.

(1)

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(b) A hot surface emits radiation of different wavelengths.

The graph in Figure 11 shows how the intensity of the radiation emitted changes with the wavelength.

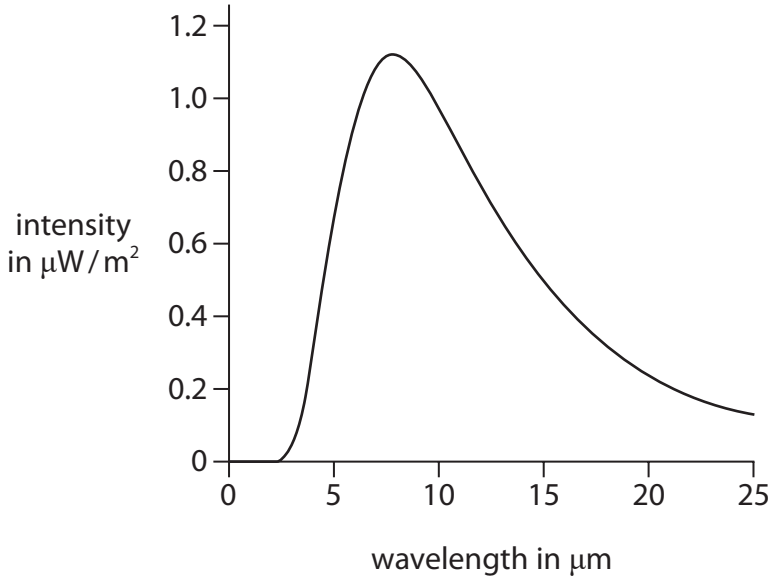

Figure 11

Describe how intensity changes with wavelength in Figure 11.

(2)

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(c) Figure 12 shows two cans, a radiant heater and some other apparatus.

The cans absorb thermal radiation from the heater.

One can has a matt black surface and the other can has a shiny silver surface.

Both cans contain water at the same temperature.

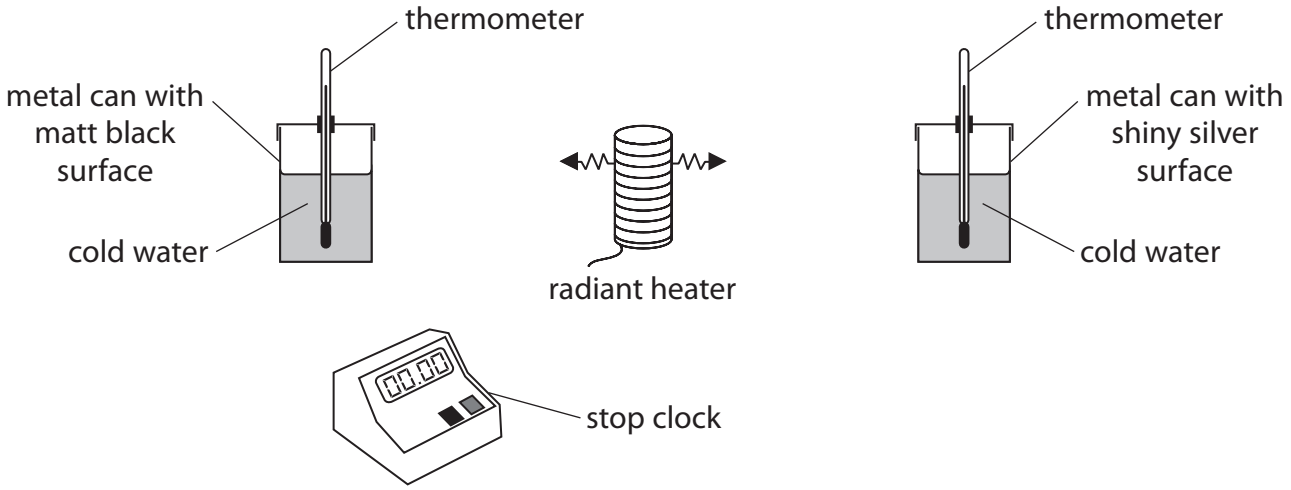

Figure 12

Describe how a student could use the apparatus in Figure 12 to determine which can is the better absorber of thermal radiation.

(4)

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(Total for Question 6 = 9 marks)

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7 This question is about radioactivity and its uses.

(a) Which of these radiations does **not** have a charge?

(1)

- ☒ **A** alpha
- ☒ **B** beta minus
- ☒ **C** beta plus
- ☒ **D** gamma

(b) Which of these radiations is used in smoke detectors?

(1)

- ☒ **A** alpha
- ☒ **B** beta minus
- ☒ **C** beta plus
- ☒ **D** gamma

(c) The diagram in Figure 13 shows a radioactive source used to check the thickness of paper.

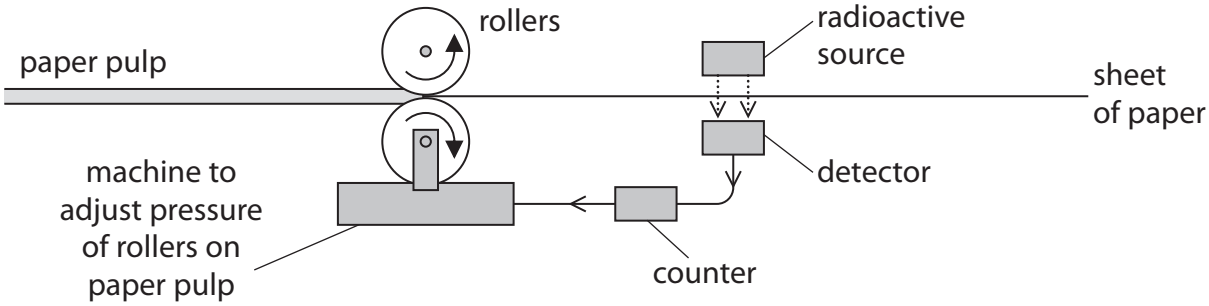

Figure 13

(i) Name the type of radiation used to check the thickness of the paper.

(1)

.....

(ii) Give the name of **one** device which could detect this type of radiation.

(1)

.....

When the paper is the correct thickness, the count rate is 4000 counts per minute.

(iii) The count rate increases when the paper gets thinner.

Give **one** reason for this increase.

(1)

.....

.....

(iv) The rollers need to be adjusted if the count rate increases by 5%.

Calculate the maximum count rate that would be allowed before the rollers need to be adjusted.

(2)

maximum count rate = ... counts per minute

*(d) Radioactivity from radioactive sources can be used in the diagnosis and treatment of cancer.

Describe **one** way radioactivity can be used in the diagnosis of cancer and **one** way radioactivity can be used in the treatment of cancer.

(6)

(Total for Question 7 = 13 marks)

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8 (a) Which of these is a scalar quantity?

(1)

- ☒ **A** acceleration
- ☒ **B** distance
- ☒ **C** force
- ☒ **D** weight

(b) A student has some cupcake cases.

One cupcake case is shown in Figure 14.

(Source: © Anton Starikov/Shutterstock)

Figure 14

The student drops a stack of cupcake cases with the base facing downwards, as shown in Figure 15.

(Source: © Elena Schweitzer/Shutterstock)

Figure 15

The speed of the falling stack of cupcake cases depends on the number of cupcake cases in the stack.

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(i) The student also has a stop clock and a metre rule.

Describe an investigation to show how the speed of the falling stack of cupcake cases depends on the number of cupcake cases in the stack.

(4)

(ii) A stack of cupcake cases has a mass of 0.005 kg.

Calculate the weight, in newtons, of the stack of cupcake cases.

Gravitational field strength = 10 N / kg

(2)

Use the equation

$$W = mg$$

weight = ... N

Figure 16 shows a cupcake case that is falling at a constant velocity.

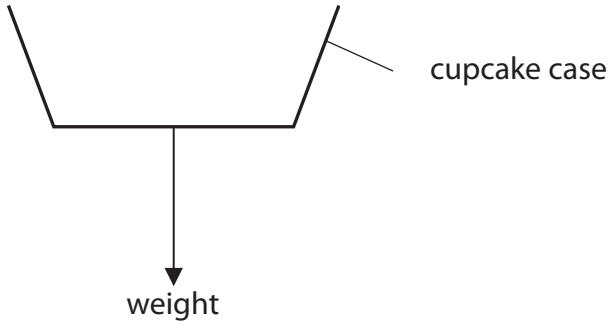

Figure 16

(iii) Draw an arrow on Figure 16 to show the force due to air resistance on the cupcake case.

(1)

(iv) State the value of the acceleration of the cupcake case when it is falling at a constant velocity

(1)

(c) A car travels along a straight road.

The car accelerates at 3 m / s^2 for a time of 7 s.

Calculate the change in velocity of the car.

Use the equation

change in velocity = acceleration × time taken

(2)

change in velocity = ... m / s

(Total for Question 8 = 11 marks)

9 (a) Figure 17 shows a football kicked against a wall.

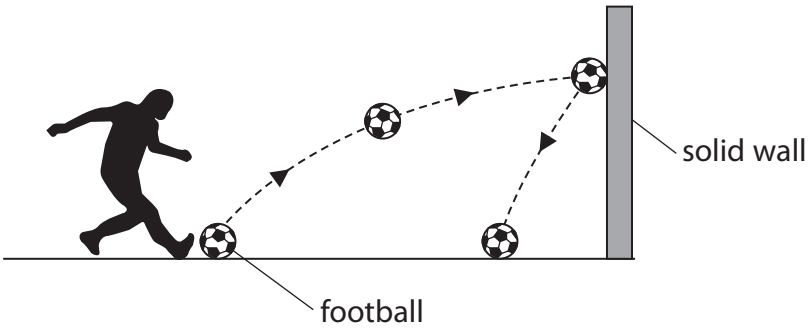

Figure 17

The football has a mass of 0.42 kg.

(i) The football gains 11 J of gravitational potential energy as it moves from the ground to the wall.

Calculate the height at which the ball hits the wall.

(3)

Gravitational field strength = 10 N / kg

Use the equation

$$\Delta GPE = m \times g \times \Delta h$$

height = ... m

(ii) Calculate the kinetic energy of the football when it is moving at a velocity of 12 m / s.

(2)

Use the equation

$$KE = \frac{1}{2} \times m \times v^2$$

kinetic energy = ... J

(iii) Describe the energy transfers that happen when the ball hits the wall.

(2)

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*(b) In the UK, electricity is generated using non-renewable and renewable energy resources.

The graph in Figure 18 shows how the amount of electricity generated by these resources changed from 2012 to 2020.

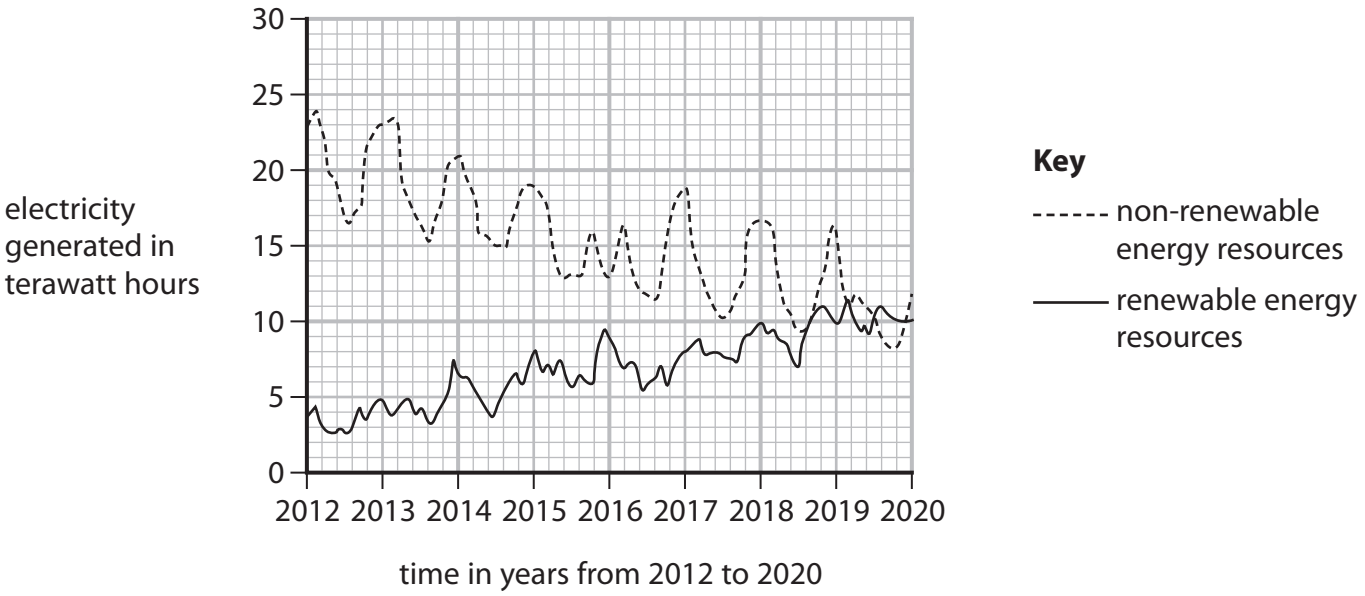

Figure 18

Explain how and why the amount of electricity generated by renewable and non-renewable energy resources has changed from 2012 to 2020.

Your answer should include

- the trends shown in Figure 18
- the change in the amount of electricity generated by at least one renewable resource
- the change in the amount of electricity generated by at least one non-renewable resource.

(6)

(Total for Question 9 = 13 marks)

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10 (a) Figure 19 shows two objects, **E** and **D**.

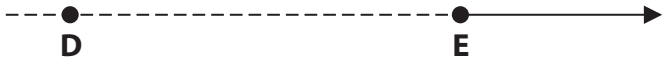

Figure 19

E emits a sound.

D detects the sound.

E is moving in the direction shown by the arrow, but **D** is not moving.

E emits a sound of wavelength 1.86 m.

D measures the wavelength of this sound as 1.98 m.

(i) Calculate the difference between the wavelength that **E** emits and the wavelength that **D** detects.

(1)

difference in wavelength = ... m

(ii) The velocity of sound is 330 m / s.

Calculate the velocity of **E**.

(2)

Use the equation

$$\text{velocity of } \mathbf{E} = \frac{\text{velocity of sound} \times \text{difference in wavelength}}{\text{wavelength } \mathbf{E} \text{ emits}}$$

velocity of **E** = ... m / s

(b) The wavelength of light emitted from distant galaxies is different when the light is detected on Earth.

Explain how this difference in wavelength shows that the Universe is expanding.

(2)

.....

.....

.....

.....

(c) CMB radiation provides evidence that the Universe had a definite beginning.

Use the table in Figure 20 to give a typical value for the wavelength of CMB radiation.

type of radiation	typical wavelength
gamma rays	1.0×10^{-12} m
X-rays	3.0×10^{-11} m
ultraviolet	200 nm
visible	600 nm
infrared	4.0 μm
microwaves	1.0 mm
radio waves	50 m

Figure 20

(2)

wavelength = ...

(d) During the evolution of a star, the nebula collapses and becomes a main sequence star.

(i) State what causes the nebula to collapse.

(1)

.....

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(ii) Explain why the nebula stops collapsing as it becomes a main sequence star.

(3)

(Total for Question 10 = 11 marks)

TOTAL FOR PAPER = 100 MARKS

Equations

(final velocity)^2 – (initial velocity)^2 = 2 × acceleration × distance $v^2 - u^2 = 2 \times a \times x$
energy transferred = current × potential difference × time $E = I \times V \times t$
potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil $V_p \times I_p = V_s \times I_s$
change in thermal energy = mass × specific heat capacity × change in temperature $\Delta Q = m \times c \times \Delta\theta$
thermal energy for a change of state = mass × specific latent heat $Q = m \times L$
$P_1 V_1 = P_2 V_2$ to calculate pressure or volume for gases of fixed mass at constant temperature
energy transferred in stretching = 0.5 × spring constant × (extension)^2 $E = ½ \times k \times x^2$

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Pearson Edexcel Level 1/Level 2 GCSE (9–1)

May–June 2023 Assessment Window

Paper reference **1PH0/1F**

Physics

PAPER 1

Foundation Tier

Equation Booklet

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Turn over ▶

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If you're taking **GCSE (9–1) Combined Science** or **GCSE (9–1) Physics**, you will need these equations:

HT = higher tier

	distance travelled = average speed × time	
	acceleration = change in velocity ÷ time taken	$a = \frac{(v-u)}{t}$
	force = mass × acceleration	$F = m \times a$
	weight = mass × gravitational field strength	$W = m \times g$
HT	**momentum = mass × velocity**	$\boldsymbol{p = m \times v}$
	change in gravitational potential energy = mass × gravitational field strength × change in vertical height	$\Delta GPE = m \times g \times \Delta h$
	kinetic energy = 1/2 × mass × (speed)^2	$KE = \frac{1}{2} \times m \times v^2$
	efficiency = $\frac{(\text{useful energy transferred by the device})}{(\text{total energy supplied to the device})}$	
	wave speed = frequency × wavelength	$v = f \times \lambda$
	wave speed = distance ÷ time	$v = \frac{x}{t}$
	work done = force × distance moved in the direction of the force	$E = F \times d$
	power = work done ÷ time taken	$P = \frac{E}{t}$
	energy transferred = charge moved × potential difference	$E = Q \times V$
	charge = current × time	$Q = I \times t$
	potential difference = current × resistance	$V = I \times R$
	power = energy transferred ÷ time taken	$P = \frac{E}{t}$
	electrical power = current × potential difference	$P = I \times V$
	electrical power = (current)^2 × resistance	$P = I^2 \times R$
	density = mass ÷ volume	$\rho = \frac{m}{V}$

	force exerted on a spring = spring constant × extension	$F = k \times x$
	(final velocity)^2 – (initial velocity)^2 = 2 × acceleration × distance	$v^2 - u^2 = 2 \times a \times x$
HT	**force = change in momentum ÷ time**	$\boldsymbol{F = \frac{(mv - mu)}{t}}$
	energy transferred = current × potential difference × time	$E = I \times V \times t$
HT	**force on a conductor at right angles to a magnetic field carrying a current = magnetic flux density × current × length**	$\boldsymbol{F = B \times I \times l}$
	For transformers with 100% efficiency, potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil	$V_P \times I_P = V_S \times I_S$
	change in thermal energy = mass × specific heat capacity × change in temperature	$\Delta Q = m \times c \times \Delta\theta$
	thermal energy for a change of state = mass × specific latent heat	$Q = m \times L$
	energy transferred in stretching = 0.5 × spring constant × (extension)^2	$E = \frac{1}{2} \times k \times x^2$

If you're taking **GCSE (9–1) Physics**, you also need these extra equations:

	moment of a force = force × distance normal to the direction of the force	
	pressure = force normal to surface ÷ area of surface	$P = \frac{F}{A}$
HT	***potential difference across primary coil*** / ***potential difference across secondary coil*** = ***number of turns in primary coil*** / ***number of turns in secondary coil***	$\boldsymbol{\frac{V_p}{V_S} = \frac{N_p}{N_S}}$
	to calculate pressure or volume for gases of fixed mass at constant temperature	$P_1 \times V_1 = P_2 \times V_2$
HT	**pressure due to a column of liquid = height of column × density of liquid × gravitational field strength**	$\boldsymbol{P = h \times \rho \times g}$

END OF EQUATION LIST

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Mark Scheme (Results)

Summer 2023

Pearson Edexcel GCSE
In Physics (1PH0)
Paper 1F

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

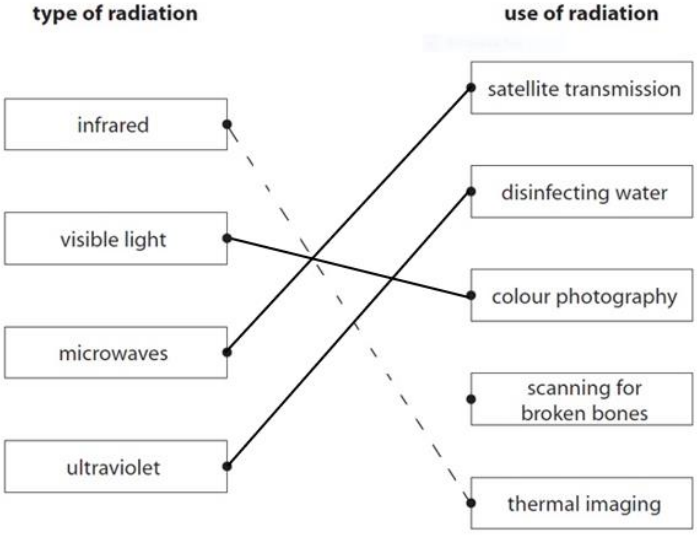
Mark schemes have been developed so that the rubrics of each mark scheme reflects the characteristics of the skills within the AO being targeted and the requirements of the command word. So for example the command word 'Explain' requires an identification of a point and then reasoning/justification of the point.

Explain questions can be asked across all AOs. The distinction comes whether the identification is via a judgment made to reach a conclusion, or, making a point through application of knowledge to reason/justify the point made through application of understanding. It is the combination and linkage of the marking points that is needed to gain full marks.

When marking questions with a 'describe' or 'explain' command word, the detailed marking guidance below should be consulted to ensure consistency of marking.

Assessment Objective		**Command Word**	
Strand	**Element**	**Describe**	**Explain**
AO1*		An answer that combines the marking points to provide a logical description	An explanation that links identification of a point with reasoning/justification(s) as required
AO2		An answer that combines the marking points to provide a logical description, showing application of knowledge and understanding	An explanation that links identification of a point (by applying knowledge) with reasoning/justification (application of understanding)
AO3	1a and 1b	An answer that combines points of interpretation/evaluation to provide a logical description	
AO3	2a and 2b		An explanation that combines identification via a judgment to reach a conclusion via justification/reasoning
AO3	3a	An answer that combines the marking points to provide a logical description of the plan/method/experiment	
AO3	3b		An explanation that combines identifying an improvement of the experimental procedure with a linked justification/reasoning

*there will be situations where an AO1 question will include elements of recall of knowledge directly from the specification (up to a maximum of 15%). These will be identified by an asterisk in the mark scheme.

Question Number	Answer	Additional guidance	Mark
1 (a) (i)		award one mark for each correct line up to three marks reject for a mark two lines starting or ending at the same box	**(3) AO1**

Question Number	Answer	Mark
1 (a)(ii)	C ultraviolet A (infrared), B (microwaves) and D (visible light) all have frequencies below that of ultraviolet	**(1) AO1**

Question Number	Answer	Additional guidance	Mark
1 (b)(i)	an explanation linking (X-rays/they) pass through/penetrate (the bags/cases) (1) to see contents/to show objects of greater density (1)	 accept see through accept look/see inside accept check contents/dangerous items	**(2) AO1**

Question Number	Answer	Additional guidance	Mark
1 (b)(ii)	an explanation linking X-rays/they are ionising (1) cause cancer/mutations (of cells/DNA) (1)	 accept harmful/dangerous accept a description of ionising accept high energy accept kill/damage cells	**(2) AO2**

Total for question 1 = 8mark

Question Number	Answer	Mark
2 (a)	**D** the reflected ray and the normal **A, B** and **C** do not describe the angle of reflection	**(1) AO1**

Question Number	Answer	Additional guidance	Mark
2 (b)(i)	Any one from:- to view distant objects /things far away (1) looking at planets /stars / space/ galaxies (1) bird watching (1)	 accept magnify distant objects accept other named astronomical objects	**(1) AO2**

Question Number	Answer	Mark
2 (b)(ii)	**C** P and Q are both converging **A** is incorrect the lens Q is not diverging **B** is incorrect the lens P is not diverging **D** is incorrect neither lens is diverging	**(1) AO3**

Question Number	Answer	Additional guidance	Mark
2 (b)(iii)	substitution (1) (power =) $\frac{1}{0.14}$ evaluation (1) 7.1 (D)	 7.14(28...) allow 7 award 1 mark for 7.1 to any other power of ten award 1 mark for correct answer as a fraction award full marks for the correct answer with no working	**(2) AO2**

Question Number	Answer	Additional guidance	Mark
2 (c)	a description including any two from window/light (from outside), lens and paper in correct order (1) move lens/paper (1) to focus (image) / to get a clear image (1)	 accept lens in front/behind window and paper in front/behind lens	**(2) AO2**

Total for question 2 = 7marks

Question Number	Answer	Mark
3 (a) (i)	**B** QR (horizontal line) **A** PQ is incorrect it shows constant acceleration **C** RS is incorrect it shows constant acceleration **D** ST is incorrect it shows constant deceleration	**(1) AO3**

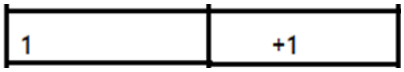
Question Number	Answer	Mark
3 (a)(ii)	**A** PQ (steeper slope shows greater acceleration) **B** QR is incorrect it shows zero acceleration **C** RS is incorrect as slope is less steep than for PQ **D** ST is incorrect as the slope is less steep than for PQ and shows deceleration	**(1) AO3**

Question Number	Answer	Additional guidance	Mark
3 (a)(iii)	substitution (1) (a=) $\frac{15(-0)}{10}$ evaluation (1) 1.5 (m/s^2)	15 seen Allow 10 divided by any number between 6 and 7 for this mark award full marks for the correct answer with no working	**(2) AO3**

Question Number	Answer	Additional guidance	Mark
3 (a)(iv)	indication that distance travelled = area under graph (1) substitution (1) (distance travelled =) 10 x 15 evaluation (1) 150 (m)	may be seen on graph accept (distance=)speed x time ignore speed = <u>distance</u> time award full marks for the correct answer with no working award 2 marks for 10 x 15 seen anywhere if no other marks awarded, 1 mark for use of 15 (m/s) or 10 (s)	**(3) AO3**

Question Number	Answer	Additional guidance	Mark
3 (b)	substitution (1) (F=) 1200 x 2.4 evaluation (1) 2900 (N)	accept 2880 (N) award one mark for power of ten error award full marks for the correct answer with no working	**(2) AO2**

Total for question 3 = 9marks

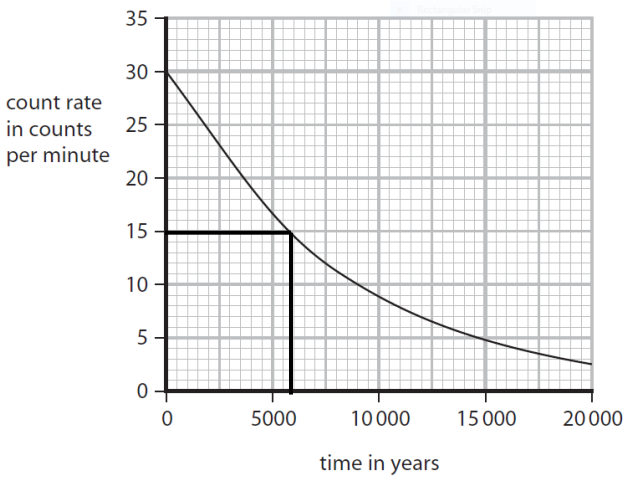
Question Number	Answer	Mark
4 a (i)	**C**  **A** is incorrect the proton has a mass of 1 not 0 **B** is incorrect the proton has a mass of 1 not 0 **D** is incorrect the proton has a charge of +1 not -1	**(1) AO1**

Question Number	Answer	Additional guidance	Mark
4 a(ii)	substitution (1) ratio = $\frac{10^{-10}}{10^{-15}}$ evaluation (1) 10^{5}	$10^{-10} : 10^{-15}$ accept suitable equivalent ratios e.g. $1 \times 10^{5} : 1$ $1 : 10^{-5}$ or $10^{5} : 1$ 1: 0.00001 or 100000:1 allow 1 mark for inverted ratios e.g. $10^{-15}: 10^{-10}$ 0.00001:1 or 1:100000 award full marks for the correct answer with no working	**(2) AO2**

Question Number	Answer	Additional guidance	Mark
4 a(iii)	an explanation linking same number / amount of (1) electrons and protons (1)	 equal number / amount of allow balanced (number / amount of) negative and positive charges ignore (neutral) neutrons reject positive/negative neutrons for 2nd marking point	**(2) AO1**

Question Number	Answer	Additional guidance	Mark
4 (b)(i)	6 / six		**(1) AO1**

Question Number	Answer	Additional guidance	Mark
4 (b)ii	8 / eight		**(1) AO2**

Question Number	Answer	Additional guidance	Mark
4 (b)(iii)	indication of horizontal line between 14 and 16 and / or vertical line between 5250 and 6250 (1)  value between 5250 (years) and 6250 (years) inclusive (1)	accept alternative indications e.g. cross on curve accept any halving pairs e.g. going between 20 cpm and 10 cpm award full marks for the correct answer with no working	**(2) AO3**

Total for question 4 = 9 marks

Question Number	Answer	Mark
5 (a)(i)	**B** the line shows the amplitude **A** is incorrect the line shows twice the amplitude **C** is incorrect the line shows half the wavelength **D** is incorrect the line shows the wavelength	**(1) AO1**

Question Number	Answer	Additional guidance	Mark
5 (a)(ii)	an explanation linking vibration/oscillation (1) perpendicular / at right angles / 90º (to the direction of travel of the wave/direction of energy transfer) (1)	 accept up and down	**(2) AO1**

Question Number	Answer	Additional guidance	Mark
5 (b)(i)	a description including count the number of waves/ripples (1) (that pass a point) in a certain time (1) OR measure the time for a certain number of waves/ripples (1) use of f = 1/T (1)	 accept use of numerical values calculate the number of waves that pass the point in a second scores 2 marks	**(2) AO1**

Question Number	Answer	Additional guidance	Mark
5 (b)(ii)	a description including any two from the waves/ripples are made to look stationary (1) measure the distance across a number of waves/wave fronts/ripples (1) calculate the wavelength from the measurements (1)	 using camera, video, strobe light, stroboscope, mobile, phone, photo(graph) accept measure the distance across a number of lines divide distance by the number of waves/ripples accept the idea of measuring the distance between one wave/ripple/line and another (successive) wave/ripple/line for 2 marks	**(2) AO1**

Question Number	Answer	Additional guidance	Mark
5 (c)	substitution (1) 0.8 =f x 4.0 rearrangement and evaluation (1) 0.2 (Hz) unit (1) Hz / s^{-1}/ per sec	 (f =) $\frac{0.8}{4.0}$ allow correct substitution into seen incorrect rearrangement award 2 marks for the correct answer with no working accept hz or hertz independent mark accept recognisable spelling	**(3) AO2**

Total for question 5 = 10marks

Question Number	Answer	Additional guidance	Mark
6 (a)(i)	any value between 21 and 54 inclusive		**(1) AO3**

Question Number	Answer	Additional guidance	Mark
6 (a)(ii)	any one from distance / separation (1) time (exposure) (1)		**(1) AO3**

Question Number	Answer	Additional guidance	Mark
6 (a)(iii)	Any one from poor conductor / reduces energy loss / (good) insulator (1) same height as detector (1)	allow heat loss for energy loss accept wood stops heat loss accept it does not conduct heat	**(1) AO3**

Question Number	Answer	Additional guidance	Mark
6 (b)	a description including any two from (at low wavelength) intensity increases (as wavelength increases) (1) after peak/at long wavelengths intensity decreases (as the wavelength increase)(1) intensity peaks between 7 and 10(μm) or between 1.0 and 1.2 ($\mu W/m^2$) (1)	allow use of data from the graph to indicate the peak	**(2)** **AO3**

Question Number	Answer	Additional guidance	Mark
6 (c)	a description including any four from **one** method **Using temperature change method:** any one control (1) start the stopclock and switch on the heater (at the same time) (1) measure over a certain time (1) measure final temperature of each (1) largest temperature difference/rise gives better absorbing surface (1) **Using time change method:** any one control (1) switch on the heater and start the stopclock (at the same time) (1) measure time taken (1) to reach a certain temperature (1) quickest time to reach a certain temperature gives better absorbing surface (1)	allow testing each can separately (two experiments) same distance from heater same volume/mass of water allow same volume/surface area of cans lids on both cans start the stopclock and measure initial temperature (at the same time) Accept 'highest temperature is better' same distance from heater same volume/mass of water allow same volume/surface area of cans lids on both cans accept 'fastest (to reach temperature) is better'	**(4)** **AO1**

Total for Question 6 =9 marks

	Answer	Mark
7 (a)	**D** gamma **A,B** and **C** all carry a charge	**(1) AO1**

	Answer	Mark
7 (b)	**A** alpha **B,C,** and **D** travel too far in air and are not sufficiently ionising	**(1) AO1**

	Answer	Additional guidance	Mark
7 (c)(i)	beta, beta (minus), β, β^-	accept beta(plus), β^+	**(1) AO1**

	Answer	Additional guidance	Mark
7 (c)(ii)	Geiger-Muller (tube)/ G-M (tube)/ GM (tube)/ Geiger (counter)	accept ratemeter do not accept radiation meter accept phonetic spellings e.g. Giga	**(1) AO1**

	Answer	Additional guidance	Mark
7 (c)(iii)	one from more (radiation) passes through (the paper) (1) OR less (radiation) is absorbed (by the paper) (1) OR less paper (for radiation) to pass through/penetrate(1)	penetrates/gets through allow easier to pass through Ignore name of particle if given	**(1) AO2**

	Answer	Additional guidance	Mark
7 c(iv)	Calculation of 5% of count rate (1) $\frac{4000 \times 5}{100}$ or 4000 x 0.05 = 200 evaluation (1) 4000 +200 = 4200	accept use of any percentage between 4% and 5% accept any value between 160 and 200 ecf for addition of incorrect calculated percentage and 4000 award full marks for any answer that rounds to 4200 without working	**(2) AO2**

Question number	Indicative content	Mark
7*(d)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 **Diagnosis** Tracers radioactive sources swallowed by or injected into patients travel around the body emit gamma radiation (from radioactive decay) gamma radiation passes out through the body detected outside the body with a gamma camera PET Scanner (more of) the tracer goes to the cancer cells gamma radiation is emitted (gamma rays) from/in different directions gamma detected by gamma cameras (3D) pictures produced on a computer screen Named tracer, e.g. technetium, iodine, fluorine **Treatment** Radiotherapy Use of gamma rays/x-rays kills cancer (cells) radiating small area of body (with gamma rays/X rays) radiation used for a short time (gamma rays) from/in different directions brachytherapy radioactive sources inside the body may not be removed put close to cancerous tumour **Ignore references to chemotherapy**	(**6**) **AO1**

Level	Mark	Descriptor
	0	• No rewardable material.
Level 1	1-2	• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents a description with some structure and coherence. (AO1)
Level 2	3-4	• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents a description that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1)

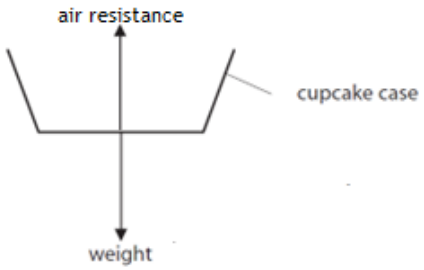
Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> isolated facts about cancer diagnosis or cancer treatment using radioactivity OR limited description about cancer diagnosis **or** limited description about cancer treatment using radioactivity OR allow isolated facts about cancer diagnosis using x-rays, C(A)T scans, MRI, ultrasound for level 1 if no other mark scored	<u>Possible candidate responses</u> Uses/emits gamma (rays) can kill cancer(ous) cells radiotherapy Cancer is treated using gamma rays CT scan is used to find tumours
Level 2	3–4	<u>Additional guidance</u> limited description about cancer diagnosis **and** limited description about cancer treatment using radioactivity OR detailed description of either cancer diagnosis or treatment using radioactivity	<u>Possible candidate responses</u> PET scans are used in diagnosis and radiotherapy is used to treat cancer OR Cancer is treated using gamma rays, the gamma rays kill the cancer cells
Level 3	5–6	<u>Additional guidance</u> detailed description about either diagnosis OR cancer treatment using radioactivity AND limited description about either cancer treatment OR diagnosis using radioactivity	<u>Possible candidate responses</u> Tracers are used in diagnosis and radiotherapy uses gamma rays to kill cells. OR Tracers emit gamma rays which pass out through the body and radiotherapy uses x-rays

Total Question 7 =13marks

Question Number	Answer	Additional guidance	Mark
8 (a)	**B** distance **A,C**, and **D** are incorrect as these are vector quantities		**(1) AO1**

Question number	Answer	Additional guidance	Mark
8 (b)(i)	A description to include any 4 from: measure height (1) measure time of fall (1) use (average) speed=distance ÷ time (1) repeat with different number of cupcake cases in the stack/more cupcake cases (1) repeat **and** average time (of fall for each stack of cupcake cases) (1) plot a graph (speed of fall against number of cupcake cases dropped) (1)	 allow 'keep same height' allow in this context hold against (fixed point on) metre rule allow 'time it' accept cupcakes for cupcake cases	**(4) AO1**

Question Number	Answer	Additional guidance	Mark
8 (b)(ii)	substitution (1) (W=)0.005 x 10 evaluation (1) 0.05 (N)	 5×10^{-2} (N) do not allow power of ten error award full marks for the correct answer with no working give full credit for use of g=9.8 or 9.81 N/kg	**(2) AO2**

Question number	Answer	Additional guidance	Mark
8 (b)(iii)	 air resistance arrow (1)	judge by eye any vertical upward arrow outside or inside the cupcake case ignore length of arrow arrow need not touch cupcake holder ignore label on arrow	**(1) AO2**

Question number	Answer	Additional guidance	Mark
8 (b) (iv)	zero / there is none / 0 / it has no acceleration	ignore 'constant' ignore units	**(1) AO2**

Question number	Answer	Additional guidance	Mark
8(c)	substitution (1) (change in velocity=) 3 x 7 evaluation (1) 21 (m/s)	 award full marks for the correct answer with no working	**(2)** **AO2**

Total for question 8 = 11marks

Question number	Answer	Additional guidance	Mark
9 (a)(i)	substitution (1) 11 = 0.42 x 10 x Δh rearrangement (1) (Δh =) $\frac{11}{0.42 \times 10}$ evaluation (1) 2.6 (m)	 accept substitution and rearrangement in either order (Δh =) $\frac{\Delta GPE}{m \times g}$ accept any value which rounds to 2.6 (m) award 2 marks for 2.6 to any other power of 10 allow 1 mark for 0.38 allow 1 mark for 46(.2) award full marks for the correct answer with no working give full credit for use of g=9.8 or 9.81 N/kg (gives 2.7 (m))	**(3) AO2**

Question number	Answer	Additional guidance	Mark
9 (a)(ii)	substitution(1) (KE=)$\frac{1}{2}$ x 0.42 x 12^2 evaluation (1) 30 (J)	 allow 30.2(4) (J) award 1 mark for 30 240 (J) award 1 mark for 2.52 (J) award 1 mark for 60.5 (J) award full marks for the correct answer with no working	**(2) AO2**

Question number	Answer	Additional guidance	Mark
9 (a)(iii)	A description including: KE/kinetic (energy store) (1) (transfers to) and **one** of: elastic (potential energy store) (1) OR thermal (energy of ball/wall/surroundings) (1) OR <u>dissipates</u> (to surroundings) (1)	 allow mechanically / mechanical transfer ignore reference to gravitational potential energy allow heat for thermal allow sound in this context ignore reference to the ground	**(2)** **AO2**

Question number	Indicative content	Mark
9*(b)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO2,AO3** **Non-renewable sources of energy** trend: less used/decrease in use (between 2012 and 2019) **fossil fuels** coal, gas, oil are running out / finite resource / sustainability argument produce carbon dioxide/ sulphur dioxide/ greenhouse gases (when burned) in power stations cause pollution/ smoke particles /damage to the environment causes climate change / global warming production of greenhouse gases needs to be reduced (for Britain to become carbon neutral) **nuclear fuels** no carbon dioxide produced radioactive waste produced safety concerns **Renewable sources of energy** trend: more used /increase in use (between 2012 and 2019) renewable and non-renewable about equally used from 2019 solar, wind, hydroelectric, tidal, geothermal, wave and biomass never run out / are sustainable do not produce carbon dioxide/ greenhouse gases (except biomass) slow down climate change / global warming	**(6)** **AO2, AO3**

Level	Mark	Descriptor
	0	• No awardable content
Level 1	1–2	• Interpretation and evaluation of the information attempted but will be limited with a focus on mainly just one variable. Demonstrates limited synthesis of understanding. (AO3) • The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3–4	• Interpretation and evaluation of the information on both variables, synthesising mostly relevant understanding. (AO3) • The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5–6	• Interpretation and evaluation of the information, demonstrating throughout the skills of synthesising relevant understanding. (AO3) • The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance isolated facts about the resources, non-renewable or renewable **OR** the trend(s) in usage	Possible candidate responses coal is non-renewable and solar is renewable non-renewables are decreasing and renewables are increasing non-renewable resources are higher on (most of) the graph
Level 2	3–4	Additional guidance trend(s) **AND** limited explanation of the renewable trend **OR** limited explanation of the non-renewable trend	Possible candidate responses use of renewable resources is increasing because renewables are sustainable OR use of non-renewable resources are decreasing because they cause global warming
Level 3	5–6	Additional guidance both trends **AND** detailed explanation of one trend **AND** some explanation of the other trend	Possible candidate responses use of renewable resources are increasing **and** the use of non-renewable resources are decreasing because non-renewable resources are running out **and** wind turbines do not produce carbon dioxide

Total for question 9 =13 marks

	Answer	Additional guidance	Mark
10 (a)(i)	(1.98-1.86) = (+/-) 0.12		**(1)** **AO2**

	Answer	Additional guidance	Mark
10(a)(ii)	(velocity =) $\frac{330 \times 0.12}{1.86}$ (1) (+/-) 21.3 (m/s) (1)	ecf from 10ai accept numbers that round to 21 (m/s) award 1,2 marks for (i) and (ii) for the correct answer for (ii) even without working	**(2)** **AO2**

	Answer	Additional guidance	Mark
10(b)	(there is) an increase in wavelength (of light) (1) shows galaxies are moving away (from Earth) (1)	allow wavelength stretches allow red shift ignore shift to red end of spectrum ignore objects / stars / planets	**(2)** **AO1**

	Answer	Additional guidance	Mark
10(c)	1(.0) (1) mm (1)	Allow values between 1.0 and 1.9 allow 1×10^{-3} m or 0.001 m for 2 marks if nothing in answer line, credit answer indicated in table	**(2)** **AO3**

	Answer	Additional guidance	Mark
10 d(i)	gravitational attraction / gravitational force (causing collapse) (1)	allow gravity ignore weight ignore gpe ignore gravitational energy	**(1)** **AO1**

	Answer	Additional guidance	Mark
10 d(ii)	An explanation linking: (gravity causing) increase in temperature (1) (until hot enough for) fusion (1) (until) balance (between gravity and fusion/thermal) (1)	 allow increase in pressure/density hydrogen to form helium allow nuclear reactions ignore fission allow equilibrium / counteracts	**(3)** **AO1**

Total for Question 10 = 11 marks.