AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.6.1.2

Properties of waves

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**14**
Available paper years	**2018–2025**

Using this booklet

1. Booklet answer numbers match the question booklet.
2. Use the original question number within marking tables.
3. Examiner comments are included where available.

Name: _____ **Date:** _____

Where a precise marking extract is unavailable, the full source document is included in an appendix. Any missing mark scheme is explicitly identified.

6.6.1.2 Properties of waves

Answer 01 · Mark scheme June 2018 | 8464/P/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	in a longitudinal wave, the oscillations / vibrations are parallel to the direction of energy transfer	allow direction of travel for energy transfer	1	AO1 6.6.1.1
	in a transverse wave, the oscillations / vibrations are perpendicular to the direction of energy transfer	allow direction of travel for energy transfer if no other mark scored allow **1** mark for (oscillations / vibrations of) longitudinal waves are parallel **and** (oscillations / vibrations of) transverse waves are perpendicular if no other mark scored allow **1** mark for transverse waves have peaks and troughs **and** longitudinal waves have compressions and rarefactions	1	
05.2		an answer of 0.063 (m) scores **3** marks		AO2 6.6.1.2
	$3.0 \times 10^8 = 4.8 \times 10^9 \times \lambda$	allow $\lambda = \frac{3.0 \times 10^8}{4.8 \times 10^9}$ this mark may be awarded if the standard form values are incorrectly converted	1	
	$\lambda = 0.0625$ (m)		1	
	$\lambda = 0.063$ (m) **or** $\lambda = 6.3 \times 10^{-2}$ (m)	allow an answer to 2 sig figs that is consistent with their calculated value of λ and has required rounding	1	

6.6.1.2 Properties of waves

Answer 01 · Mark scheme

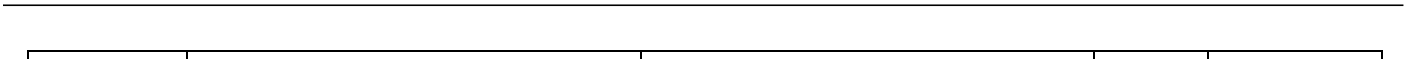
June 2018 | 8464/P/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	any **three** from: • (the car aerial) absorbs radio waves or energy • electrons are made to vibrate (in the aerial) • creating an alternating current (in the aerial circuit) • the (signal) frequency is the same (as the radio wave)		3	AO1 6.6.2.3
Total			**8**	

6.6.1.2 Properties of waves

Answer 01 · Mark scheme

June 2018 | 8464/P/2H | Original Q5



6.6.1.2 Properties of waves

Answer 02 · Mark scheme

June 2019 | 8464/P/2H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
01.1	(4 - 0) + (10 - 7) **or** 4 + 3 **or** 10 - 3 7 (s)	an answer of 7 (s) gains **2** marks	1 1	AO2 6.5.4.1.5	E
01.2	gradient = $\frac{0-2}{24-14}$ (-)0.2 (m/s^2)	an answer of 0.2 (m/s^2) gains **2** marks allow readings from any two points correctly substituted allow correct use of $a = \frac{\Delta v}{t}$	1 1	AO2 6.5.4.1.5	E
01.3	(there are no wires) to get tangled / disconnected	allow easier to move arms allow wires are inconvenient allow easier to transfer data	1	AO3 6.6.2.4	E
01.4	wave speed = frequency × wavelength	allow v = f λ allow any correct re-arrangement	1	AO1 6.6.1.2	E
01.5	300 000 000 = 2 400 000 000 × λ λ = $\frac{300\,000\,000}{2\,400\,000\,000}$ λ = 0.125 (m)	an answer of 0.125 (m) or 0.13 (m) scores **3** marks allow λ = 0.13 (m)	1 1 1	AO2 6.6.1.2	E
01.6	range is far enough (for most uses) power is not too great so the battery will not drain quickly	allow power not too great so the phone will not overheat allow the range per milliwatt is greatest or 4 metres	1 1	AO3 6.6.2.4	E

6.6.1.2 Properties of waves

Answer 02 · Mark scheme

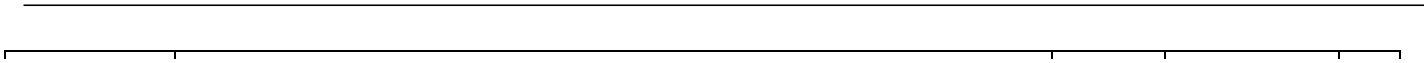
June 2019 | 8464/P/2H | Original Q1

Total			**11**		

6.6.1.2 Properties of waves

Answer 02 · Mark scheme

June 2019 | 8464/P/2H | Original Q1



6.6.1.2 Properties of waves

Answer 03 · Mark scheme

June 2019 | 8464/P/2H | Original Q2

Question	Answers	Mark	AO / Spec. Ref.	ID
02.1	**Level 3:** The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	5–6	AO1 6.6.1.2	E
	Level 2: The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.	3–4		
	Level 1: The design/plan would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2		
	No relevant content.	0		
	Indicative content • If two quantities have been determined, v = f λ can be used to find the third. **Frequency** • use a stopclock • count the number of waves passing a point in a fixed time period • divide the time by the number of waves to determine the time for one wave, T • f = 1/T • read the frequency off the oscillator **Wavelength** • use a camera to freeze the image • use a metre rule to measure the distance between two wavefronts • count the number of waves between the wavefronts • divide distance by the number of waves to determine λ **Velocity** • determine a mean value of frequency • determine a mean value of wavelength • measure the time it takes one wavefront to travel the length of the screen • measure the length of the screen • speed = distance / time to access Level 3 there must be a description of how frequency, wavelength and velocity can be determined			

6.6.1.2 Properties of waves

Answer 03 · Mark scheme

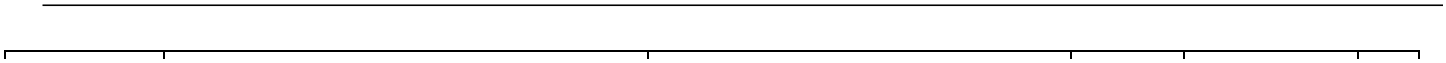
June 2019 | 8464/P/2H | Original Q2

02.2	(the duck) moves perpendicular to the direction of wave travel	duck moves up and down is insufficient	1	AO2 6.6.1.1	E
02.3	mean maximum height = 511 **and** mean minimum height = 500 511 – 500 = 11 11 / 2 = 5.5 (mm)	an answer of 5.5 gains **3** (mm) marks allow a calculated difference from incorrect means allow their difference divided by 2 any correct method of determining the mean amplitude can score **3** marks	1 1 1	AO2 6.6.1.2	E
Total			**10**		

6.6.1.2 Properties of waves

Answer 03 · Mark scheme

June 2019 | 8464/P/2H | Original Q2



6.6.1.2 Properties of waves

Answer 04 · Mark scheme

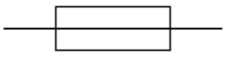
June 2019 | 8464/P/2H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
7.1	speed / velocity in the glass is lower	speed / velocity changes is insufficient allow the refractive index of glass is higher than that of air allow glass has a higher optical density than air	1	AO1 6.6.2.2	E
	so the edge of the wave(front) entering the glass slows down		1		
	but the part of the wave(front) in the air continues at the higher speed / velocity (causing a change in direction)		1		
7.2	correct ray in the prism bent towards the normal		1	AO1 6.2.2.2	E
	second normal at 90° at the point the ray emerges		1		
	correct emergent ray bent away from the normal	this mark can be awarded without a normal line drawn	1		
7.3	violet has the shortest wavelength (400 nm)		1	AO3 6.2.2.2	E
	violet light travels the slowest in water		1		
	violet light undergoes the greatest change in speed (and direction)		1		
Total			9		

6.6.1.2 Properties of waves

Answer 05 · Mark scheme

November 2020 | 8464/P/1H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	swap the blue wire and the green and yellow wire	allow connect the blue wire to the neutral pin and the yellow and green wire to the earth pin. allow swap the earth and neutral wires ignore the earth wire and neutral wire are wrongly connected	1	AO2 6.2.3.2
01.2	230 (V) 50 (Hz)		1 1	AO1 6.2.3.1 6.2.3.2
01.3	0 (V)		1	AO1 6.2.3.2
01.4			1	AO1 6.2.1.1
01.5	the person could get an electric shock because there is a current in the person	allow so the person could be electrocuted allow because the person provides a connection (from the washing machine) to earth allow because there is a potential difference across the person	1 1	AO3 6.2.3.2

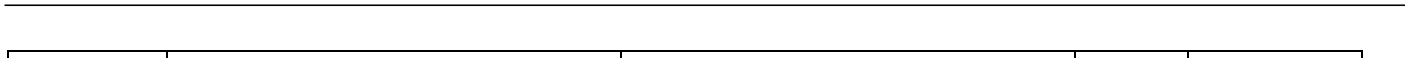
6.6.1.2 Properties of waves

01.6	the charge flows through the earth wire (instead of the person) because the resistance of the earth wire is much less than that of a person	 allow so the case does not become live allow so the fuse will break / melt / blow	1 1	AO3 6.2.3.2
Total			**9**	

6.6.1.2 Properties of waves

Answer 05 · Mark scheme

November 2020 | 8464/P/1H | Original Q1



6.6.1.2 Properties of waves

Answer 06 · Mark scheme

November 2021 | 8464/P/2H | Original Q3

Question	Answers	Mark	AO / Spec. Ref.
03.1	**Level 2:** The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	3–4	AO1 6.6.1.2
	Level 1: The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.	1–2	
	No relevant content	0	
	Indicative content **Wavelength** • place a metre rule at the side of the screen perpendicular to the wave fronts • use the metre rule to measure the length of the screen • take a photograph of the shadow on the screen • count the number of complete waves on the screen • determine the wavelength by dividing the length of the by the number of complete waves **or** • place a metre rule at the side of the screen perpendicular to the wave fronts • take a photograph of the shadow on the screen • use the metre rule to measure the distance between two wave front **Frequency** • count the number of waves that pass a given point • time how long it takes for the waves to pass that point using a stop clock • frequency is number of waves divided by time taken **or** • put a stop clock on the screen • use a digital video camera to record the waves passing a point • replay in slow motion and count the number of waves passing a point in 1 second There must be a description of both frequency and wavelength measurement to access level 2		

6.6.1.2 Properties of waves

Answer 06 · Mark scheme

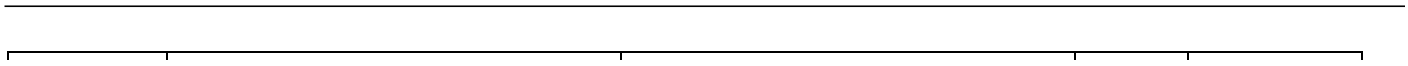
November 2021 | 8464/P/2H | Original Q3

03.2	mean f = 9.5 Hz mean λ = 0.020 m v = 9.5 × 0.020 v = 0.19 (m/s) **or** v = 9.8 × 0.017 **and** v = 9.4 × 0.022 **and** v = 9.3 × 0.021 (2) $v = \frac{(1.67 + 2.07 + 1.95)}{3}$ (1) v = 0.19 (m/s) (1)	 allow a correct substitution of an incorrect value of mean frequency and/or wavelength allow a correct calculation using an incorrect value of mean frequency and/or wavelength allow a maximum of **2** marks if a single pair of values is used	1 1 1 1	AO2 6.6.1.2
03.3	reduces the effect of random errors	allow anomalous readings can be discarded before calculating a mean	1	AO1 6.6.1.2
03.4	deeper water means longer wavelength because v increases and f is constant	 allow for a fixed frequency period is constant	1 1	AO3 6.6.1.2
Total			**11**	

6.6.1.2 Properties of waves

Answer 06 · Mark scheme

November 2021 | 8464/P/2H | Original Q3



6.6.1.2 Properties of waves

Answer 07 · Mark scheme

November 2021 | 8464/P/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	different temperatures emit different intensities of infrared which are represented (on the infrared camera) as different shades / colours	 allow wavelength / frequency / amount for intensity throughout	1 1	AO1 AO3 6.6.2.4
05.2	visible light		1	AO3 6.6.2.1
05.3	both ionising radiation so some risk of cancer the whole body is irradiated by gamma rays when an X-ray is taken only part of the body is exposed exposure time for gamma rays is longer		1 1 1 1	AO1 AO3 AO3 AO3 6.6.2.3
05.4	$1.2 \times 10^{-13} = F \times 0.015$ $F = \frac{1.2 \times 10^{-13}}{0.015}$ $F = 8.0 \times 10^{-12}$ N	 allow a correct rearrangement using an incorrectly / not converted value of s allow 8×10^{-12} allow a correct calculation using an incorrectly / not converted value of s	1 1 1	AO2 6.5.2

6.6.1.2 Properties of waves

Answer 07 · Mark scheme

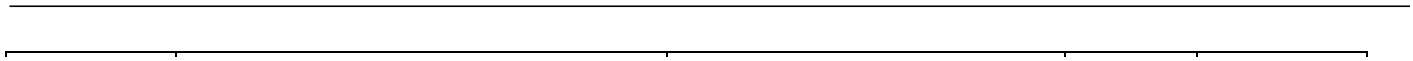
November 2021 | 8464/P/2H | Original Q5

05.5	some of the energy of the electrons causes heating (therefore) increasing the temperature (so using tungsten) allows more electrons to be collided per second than using any other metal	 allow (so using tungsten) enables more energy per second to be transferred than using any other metal	1 1 1	AO1 AO3 AO3 6.5.2
Total			**13**	

6.6.1.2 Properties of waves

Answer 07 · Mark scheme

November 2021 | 8464/P/2H | Original Q5



6.6.1.2 Properties of waves

Answer 08 · Mark scheme

June 2022 | 8464/P/2H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	**A** = rarefaction **B** = wavelength		1 1	AO1 6.6.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	f = 4000 Hz		1	AO2
	$T = \frac{1}{4000}$	allow a correct substitution using an incorrectly / not converted value of f	1	AO2
	T = 0.00025	allow a correct calculation using an incorrectly / not converted value of f	1	AO2
	seconds **or** s		1	AO1 6.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	wave speed = frequency × wavelength **or** $v = f\lambda$		1	AO1 6.6.1.2

6.6.1.2 Properties of waves

Answer 08 · Mark scheme

June 2022 | 8464/P/2H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	$v = 348$	allow a value in the range 347 to 348 subsequent marks may only be awarded if value for v is in the range 343 to 349	1	AO2 6.6.1.2
	$348 = 300 \times \lambda$	allow a correct substitution using an incorrect value of v read from graph	1	
	$\lambda = \frac{348}{300}$	allow a correct rearrangement using an incorrect value of v read from graph	1	
	1.16 (m)	allow 1.2 (m) allow a correct calculation using an incorrect value of v read from graph allow a maximum of **2** marks for use of $v = 330$ m/s	1	

Total Question 1		**11**

6.6.1.2 Properties of waves

Answer 09 · Mark scheme

June 2023 | 8464/P/2H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	**A** radio waves **B** microwaves **C** X-rays	allow **1** mark if 2 correct	2	AO1 6.6.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	**Similarity** any **one** from: • same speed (in a vacuum) • both transfer energy • both transverse **Difference** any **one** from: • gamma has a higher frequency • gamma has a shorter wavelength • gamma is more ionising • gamma is more penetrating	allow both can travel through a vacuum allow both are ionising allow both can harm living tissue allow both can be used for medical treatment / imaging allow gamma has more energy	1 1	AO1 6.6.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	refraction		1	AO1 6.6.2.2

6.6.1.2 Properties of waves

Answer 09 · Mark scheme

June 2023 | 8464/P/2H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	wave speed = frequency × wavelength **or** $v = f\lambda$		1	AO1 6.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	$3.0 \times 10^{8} = f \times 5.0 \times 10^{-7}$ $f = \frac{3.0 \times 10^{8}}{5.0 \times 10^{-7}}$ $f = 6 \times 10^{14}$ (Hz)	 allow a correct rearrangement using incorrect powers of 10 allow a correct calculation of f using incorrect powers of 10 allow 6.0×10^{14} (Hz)	1 1 1	AO2 6.6.1.2

Total Question 1	9

Answer 10 · Mark scheme

June 2023 | 8464/P/2H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	distance across all 8 wavelengths = 113 (mm) their distance × 5.0 wavelength = 70 (mm)	allow a range from 108 (mm) to 118 (mm) allow a range from 68 mm to 72 mm	1 1 1	AO2 6.6.1.2 RPA20

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	97 × 5 = (96 + 99 + 97 + **X** + 97) **X** = 96	allow **X** = (97 × 5) – (96 + 99 + 97 + 97)	1 1	AO2 6.6.1.2 RPA20

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	the spread of values about the mean is very small		1	AO3 6.6.1.2 RPA20

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4	the oscillations / vibrations in longitudinal waves are parallel to the direction of energy transfer (whereas) the oscillations / vibrations in transverse waves are perpendicular to the direction of energy transfer	allow direction of wave travel for direction of energy transfer if no other mark awarded allow 1 mark for oscillations / vibrations in longitudinal waves are parallel **and** oscillations / vibrations in transverse waves are perpendicular	1 1	AO1 6.6.1.1

Total Question 3	8

6.6.1.2 Properties of waves

Answer 11 · Mark scheme

June 2024 | 8464/P/2H | Original Q1

Question 1

Question	Answers	Mark	AO / Spec. Ref.
01.1	**Level 2:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	3–4	AO1 6.6.1.2 RPA20
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative content • use the signal generator to adjust the frequency • keep the number of masses the same • move the wooden bridge • observe a steady / stationary wave pattern • use the metre rule to measure the wavelength • repeat using different values of frequency • repeat for different stationary wave patterns		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	$v = f \times \lambda$		1	AO1 6.6.1.2

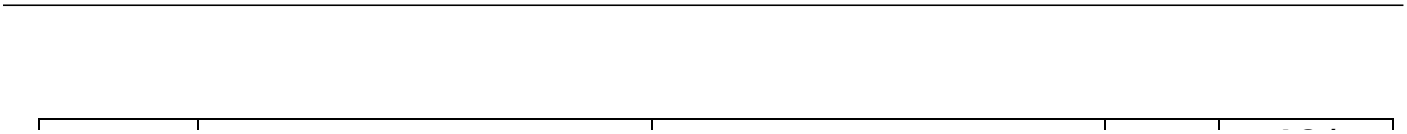
Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	$35.1 = 45.0 \times \lambda$		1	AO2 6.6.1.2
	$\lambda = \frac{35.1}{45.0}$		1	
	$\lambda = 0.78$	allow 0.780	1	

Total Question 1	8

6.6.1.2 Properties of waves

Answer 11 · Mark scheme

June 2024 | 8464/P/2H | Original Q1



6.6.1.2 Properties of waves

Answer 12 · Mark scheme

June 2024 | 8464/P/2H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	speed (in a vacuum/air) **or** transfer energy	ignore they can travel through air allow they can be reflected / refracted	1	AO1 6.6.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	oscillations / vibrations are perpendicular to the direction of energy transfer	allow wave travel for energy transfer	1	AO1 6.6.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	microwaves	allow radio waves	1	AO1 6.6.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4	violet	allow purple	1	AO1 6.6.2.1

6.6.1.2 Properties of waves

Answer 12 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.5	any **two** from • (ultraviolet and /or X-rays and / or gamma rays) can cause mutations in genes / DNA • ultraviolet can cause skin to age and / or skin cancer • X-rays and / or gamma rays increase the risk of cancers	 allow can damage / kill cells ignore mutations in cells allow ultraviolet can cause sunburn or eye damage allow X-rays and / or gamma rays can cause cancers if no other mark awarded allow **1** mark for (the three highest frequency groups) can cause cancer	2	AO1 6.6.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.6	$4.0 \times 10^{-10} = \frac{1}{\text{frequency}}$ $\text{frequency} = \frac{1}{4.0 \times 10^{-10}}$ 2.5×10^{9} (Hz)	 only award if answer is in standard form	1 1 1	AO2 6.6.1.2

6.6.1.2 Properties of waves

Answer 12 · Mark scheme

June 2024 | 8464/P/2H | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.7	radio waves are produced (by the transmitter)	allow microwaves are produced (by the transmitter)	1	AO1 6.7.2.1
	the detector absorbs the waves / energy		1	
	(which produces) an alternating current	allow causing electrons to oscillate	1	
	with the same frequency as the (transmitted) waves	allow with the same frequency as the oscillations in the transmitter	1	

Total Question 3	13

6.6.1.2 Properties of waves

Answer 13 · Mark scheme

June 2025 | 8464/P/1H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	230 (V) 50 (Hz)	allow about 230 (V)	1 1	AO1 6.2.3.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	live – brown neutral – blue		1 1	AO1 6.2.3.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	alternating (potential difference) continuously changes direction direct (potential difference) is always in the same direction		1 1	AO1 6.2.3.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	energy / power is transferred by the laptop (when being used) (so) the power delivered to the battery is reduced	 allow (so) the rate at which energy is transferred to the battery is lower	1 1	AO2 AO3 6.1.1.4 6.1.2.1

6.6.1.2 Properties of waves

Answer 13 · Mark scheme

June 2025 | 8464/P/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	$P = 15 \times 4.8$		1	AO2 6.2.4.1
	$P = 72$ (W)		1	6.2.4.2 6.1.1.4
	$\Delta P = 97 - 72 = 25$ (W)		1	
	$25 = \frac{225\,000}{t}$	subsequent marks may be awarded if an incorrect / not converted value of E is used.	1	
	$t = 9000$ (s)		1	
	$t = 2.5$ (hours)		1	

Total Question 5	14

Answer 14 · Mark scheme

June 2025 | 8464/P/2H | Original Q3

Question 3

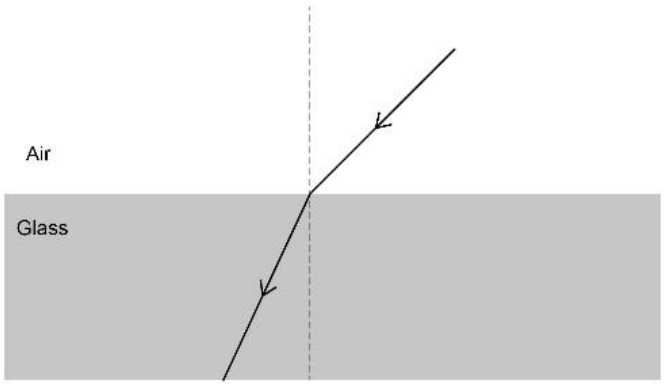
Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	oscillations / vibrations are perpendicular to the direction of energy transfer	allow oscillations / vibrations are perpendicular to the direction of wave travel allow **1** mark for oscillations/ vibrations are perpendicular	2	AO1 6.6.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	skin cancer **or** causes skin to age (prematurely)	allow skin cell mutation ignore cancer unqualified	1	AO1 6.6.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	shorter		1	AO1 6.6.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4	$3.00 \times 10^{8} = 6.25 \times 10^{14} \times \lambda$ $\lambda = \dfrac{3.00 \times 10^{8}}{6.25 \times 10^{14}}$ $\lambda = 4.80 \times 10^{-7}$ (m) $\lambda = 480$ (nm)	 allow a correct conversion to nm of their incorrectly calculated value of λ using the numbers from the question	1 1 1 1	AO2 6.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.5	the speed of the light / waves / wavefronts decreases (when entering the lens) (so) one end of the wavefront slows before the other end	allow the speed of light / waves / wavefronts is less in the lens (than in air) ignore lens has a higher density than air ignore references to refractive index	1 1	AO1 6.6.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.6	normal line drawn ray drawn with an angle of refraction of 28°  ignore ray below the glass	allow a normal line that only extends from the boundary into the glass	1 1	AO2 6.6.2.2

Total Question 3	**12**

6.6.1.2 Properties of waves

Answer 01 · Examiner comments

June 2018 | 8464/P/2H | Original Q5

Question 5 (standard & standard / high demand)

05.1 Nearly 13% gave accurate answers to score both marks. A further 20% were able to score a compensation mark by vague references to parallel and perpendicular, but it was clear that many students do not realise the importance of what is oscillating and the direction of energy transfer. There were many vague incorrect descriptions of 'up and down' and 'side to side'.

05.2 25% gained full marks, and a further 18% gained two marks, usually not giving the answer to two significant figures. There were a large number of responses using an incorrect rearrangement of the equation and generally the use of standard form was not the cause of the errors.

Answer 01 · Examiner comments

June 2018 | 8464/P/2H | Original Q5

05.3 This was very poorly done, with just over 1% gaining full marks. There were many vague responses and a significant number of candidates wrote about transverse and longitudinal waves. There was also considerable reference to radio waves being reflected off the ionosphere.

A significant minority of students did not attempt this question which might suggest that they were unfamiliar with the material.

6.6.1.2 Properties of waves

Answer 06 · Examiner comments

November 2021 | 8464/P/2H | Original Q3

Question 3 (standard demand and standard/high demand)

03.1 Over 10% of students did not attempt the question. Very few students demonstrated a good understanding of this Required Practical Activity. Approximately 35% of students were able to suggest an appropriate measurement using correct equipment, but did not give any description of what these measurements were for. Fewer than 10% of students wrote level 2 answers that would produce a valid outcome.

03.2 Nearly 30% of students calculated a mean value for the wavelength and the frequency, and then went on to determine the speed the wave. These students were given 3 marks. Only approximately 5% of students also converted the wavelength from cm to m and were awarded full marks.

Over 30% of students were awarded 1 or 2 marks for a mean calculation or for calculating the speed without calculating means first.

03.3 15% of students correctly gave the advantage of taking repeat readings and then calculating a mean as reducing the effect of random errors. Most incorrect answers stated that it makes the answer more accurate.

03.4 Just under 20% of students scored marks on this question. Most that scored 0 marks did not refer to the information given in the question. Many stated that the deeper the water the slower the wave.

Answer 07 · Examiner comments

November 2021 | 8464/P/2H | Original Q5

Question 5 (standard/high demand and high demand)

05.1 Only 10% of students scored marks on this question. At high demand it is expected that where a question follows a figure, students should use information from the figure. Very few students linked the amount of infra-red radiation to temperature, or stated that different temperatures are displayed at different colours, despite that information being given in Figure 8.

05.2 This was a demanding question - students had to compare wavelengths given in nm and mm and in standard form. They then had to use their understanding of the electromagnetic spectrum. Less than 30% of students answered this question correctly.

05.3 The vast majority of the 40% of students that scored marks on this question only scored 1 mark, and that was mostly for saying that there is some risk of cancer with both.

05.4 This question performed as expected with 30% of students scoring 2 marks. Only 8% of students included the conversion to gain full marks.

6.6.1.2 Properties of waves

Answer 07 · Examiner comments November 2021 | 8464/P/2H | Original Q5

05.5 20% of students gained at least 1 mark. Most of those stated that the energy from the electrons would cause heating and increase the temperature. Some went on to say that tungsten could be heated to a higher temperature than any other metal. No student scored full marks for explaining this meant that more electrons could be collided.

Answer 08 · Examiner comments June 2022 | 8464/P/2H | Original Q1

Question 1 (Standard demand)

01.1 Of the 90% of students that scored marks on this question, the majority were able to identify the wavelength for 1 mark. 35% of students also identified the rarefaction to score 2 marks.

01.2 10% of students scored full marks on this question. 25% of students scored 3 marks, the majority of whom did the conversion, but did not give the unit. 50% of students scored 2 marks on this question, failing to do the conversion or recall the unit.

01.3 Over 99% of students were able to select the correct equation.

01.4 The majority of students understood what was required to answer this question. Nearly 65% of students gained full marks. Some students read the correct value from the graph, but then wrote this as their final answer. Some students just multiplied 300 by 28.

6.6.1.2 Properties of waves

Answer 09 · Examiner comments

June 2023 | 8464/P/2H | Original Q1

Question 1 (Standard demand)

01.1 60% of students correctly identified all three parts of the electromagnetic spectrum and scored both marks. However, 30% of students scored no marks.

01.2 50% of students were able to gain at least one mark on this question. The similarity was more accessible and was how the majority of the 35% that scored one mark got the mark. Many identified that both waves are transverse. For the difference, most students did not refer to a property of electromagnetic waves.

01.3 A little over 65% of students correctly identified that the process is called refraction.

01.4 Over 99% of students gained the mark. Students were given the equation sheet, which will have contributed to the overall performance on this question.

01.5 Over 70% of students were able to substitute correctly and give the correct answer to the question, to the correct order of magnitude. Approximately 20% of students correctly rearranged and substituted but did not use their calculator to evaluate the numbers in standard form, so scored 2 marks.

6.6.1.2 Properties of waves

Answer 10 · Examiner comments

June 2023 | 8464/P/2H | Original Q3

Question 3 (standard demand and standard/high demand)

03.1 Many students found this question challenging, even though this forms part of a required practical. Approximately 50% of students scored marks, but only a small percentage arcuately measured across a number of wavelengths, and then applied the scale factor correctly and scored full marks. The majority of students that scored one mark measured across one wavelength and multiplied that by 5.

03.2 This calculation was well answered, with 90% of students scoring two marks.

03.3 Only 40% of students knew that for precise readings the spread of values about the mean is very small.

03.4 25% of students scored marks on this question. 15% of students scored two marks. Of the 10% of students who scored one mark, most wrote vague answers stating that longitudinal waves are parallel and transverse waves are perpendicular, but didn't mention oscillations or energy transfer.

Answer 11 · Examiner comments

June 2024 | 8464/P/2H | Original Q1

Question 1 (standard demand)

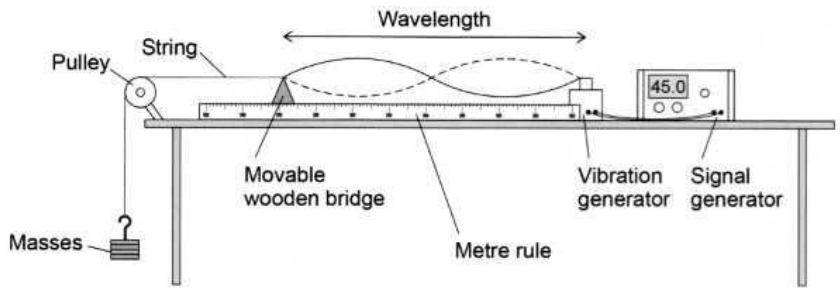
01.1 Even the Higher tier students found this question difficult with 10% gaining more than 2 marks. Although based on Required Practical Activity 20, for most students this appeared to be an unfamiliar experiment and they were unable to answer the question.

To access Level 2, the method needed to lead to a *valid* outcome: most students just described what was shown to them in Figure 11 and did not add anything of value. Most of the students that did score marks were able to describe changing the frequency with the signal generator or measuring the wavelength with a ruler.

0 1 A teacher demonstrated how the frequency of a wave on a string affects the wavelength of the wave.

Figure 1 shows the equipment used.

Figure 1



The frequency of the signal generator is adjusted so that the wave shown in **Figure 1** is seen.

At this frequency the string vibrates between the two positions shown in **Figure 1**.

0 1 . 1 Describe a method the teacher could use to investigate how the frequency of the wave affects the wavelength.

[4 marks]

you would first set up by ~~putting~~ adding a metre ruler on the table place a signal generator and connect it to the vibration generator then connect a piece of string along the top of the vibration generator attaching it to the pulley adding masses to keep it ~~tight~~ balanced then move the movable wooden bridge to increase/decrease the string length and use the results on the signal generator to record the measurements.

In this response the student has mostly just written a description of the equipment set-up in the diagram. There is nothing of relevance to a method here, so no marks are awarded.

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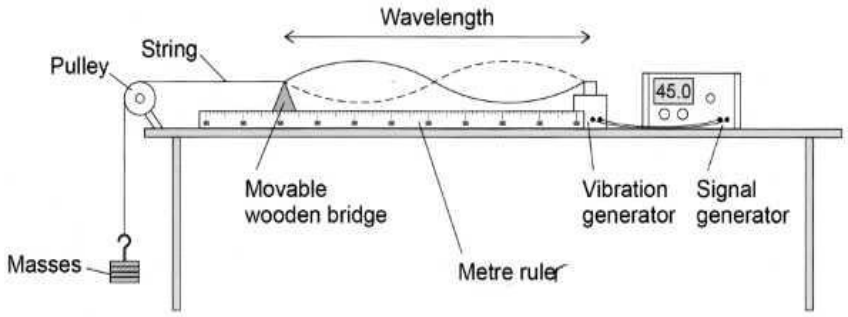
6.6.1.2 Properties of waves

Answer 11 · Examiner comments June 2024 | 8464/P/2H | Original Q1

0 6 A teacher demonstrated how the frequency of a wave on a string affects the wavelength of the wave.

Figure 11 shows the equipment used.

Figure 11



The frequency of the signal generator is adjusted so that the wave shown in **Figure 11** is seen.

At this frequency the string vibrates between the two positions shown in **Figure 11**.

0 6 . 1 Describe a method the teacher could use to investigate how the frequency of the wave affects the wavelength.

[4 marks]

To investigate how the frequency of the wave- ~~length~~ affects the wave, the teacher ~~the~~ could adjust the frequency of the signal generator and measure the wavelength of the string with the metre ruler, recording the results. Repeating this a few times; everytime adjusting the frequency of the signal generator, the teacher can then look at the results and see if there is any correlation between the two (the frequency of the wave and the wavelength.)

In this response from a Foundation tier paper the student has described how to change the independent variable and then how to measure the dependent variable. This answer does not quite get into Level 2 as it is not clear that this is repeated at different frequencies and it would not lead to a valid outcome. However, 2 marks are awarded.

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6.6.1.2 Properties of waves

Answer 11 · Examiner comments June 2024 | 8464/P/2H | Original Q1

01.2 This question was well answered with nearly all students selecting the correct equation.

01.3 This calculation was very well answered with approximately 90% of students gaining full marks. Most students that correctly substituted into the equation were able to correctly rearrange and evaluate. Most students that did not score any marks substituted into an incorrectly rearranged equation.

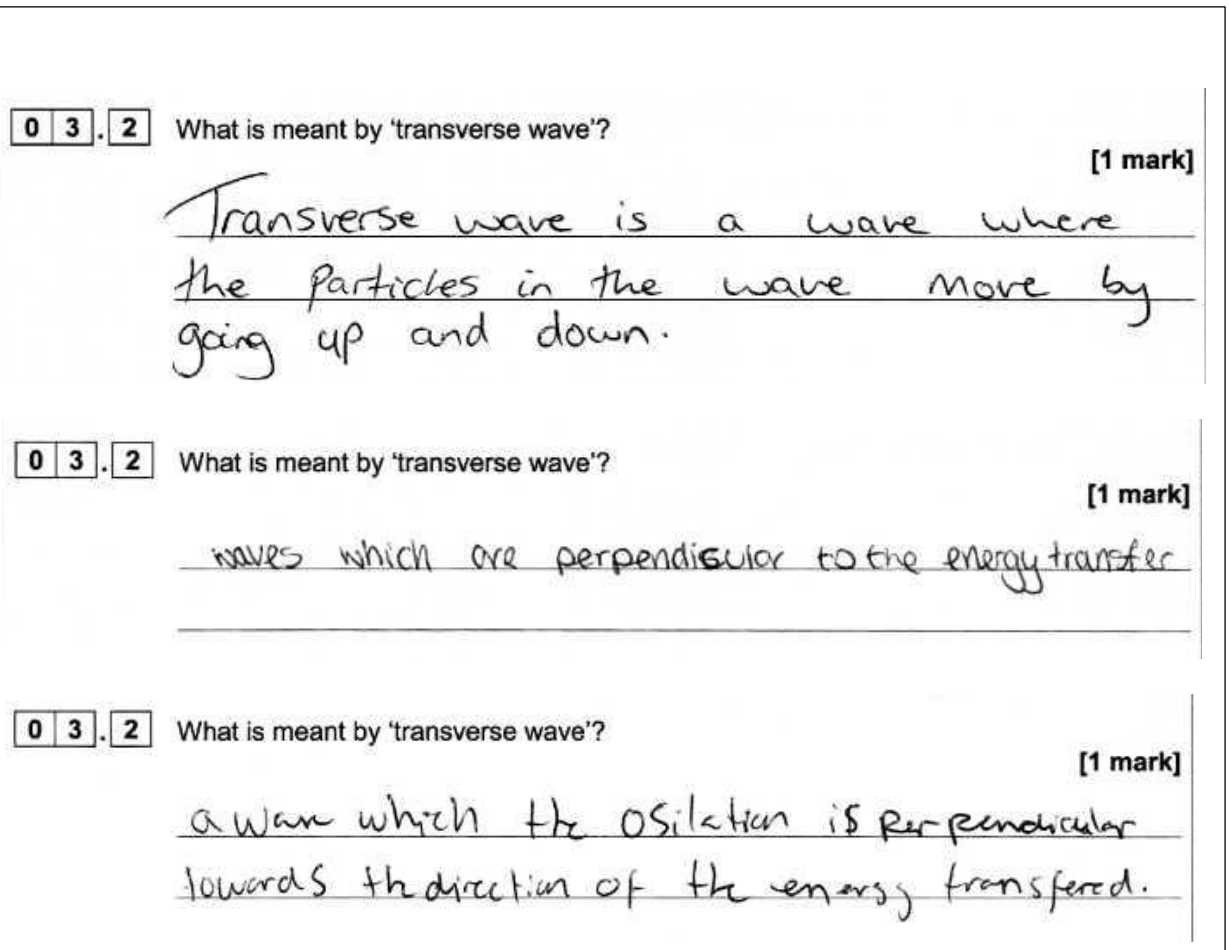
Answer 12 · Examiner comments

June 2024 | 8464/P/2H | Original Q3

Question 3 (standard, standard/high & high demand)

03.1 This question proved to be more demanding than expected, with just over 20% of students able to give a correct property of electromagnetic waves. Many students simply repeated the wording of the stem (that they can travel through a vacuum) even though they were asked of one *other* property. Some students attempted to describe a transverse wave.

03.2 Just over 20% of students were able to describe a transverse wave. Most demonstrated some understanding, but answers were often insufficient or too vague for the mark. When describing transverse waves, it must be clear that oscillations are perpendicular to the direction of energy transfer. Most answers were missing some part of the description.



0 3 . 2 What is meant by 'transverse wave'?

[1 mark]

Transverse wave is a wave where the particles in the wave move by going up and down.

0 3 . 2 What is meant by 'transverse wave'?

[1 mark]

waves which are perpendicular to the energy transfer

0 3 . 2 What is meant by 'transverse wave'?

[1 mark]

a wave which the oscilation is perpendicular towards the direction of the energy transfered.

The first two examples here are not sufficient to gain the marks. In the first, the student demonstrates some understanding but the language is very vague and there is no mention of energy transfer. The second response gives an *almost* complete description but there is no mention of oscillations/vibrations so the mark cannot be awarded.

The third response has all the required aspects of the description so the mark is awarded.

03.3 This AO1 question was well answered with 85% of students giving the correct response.

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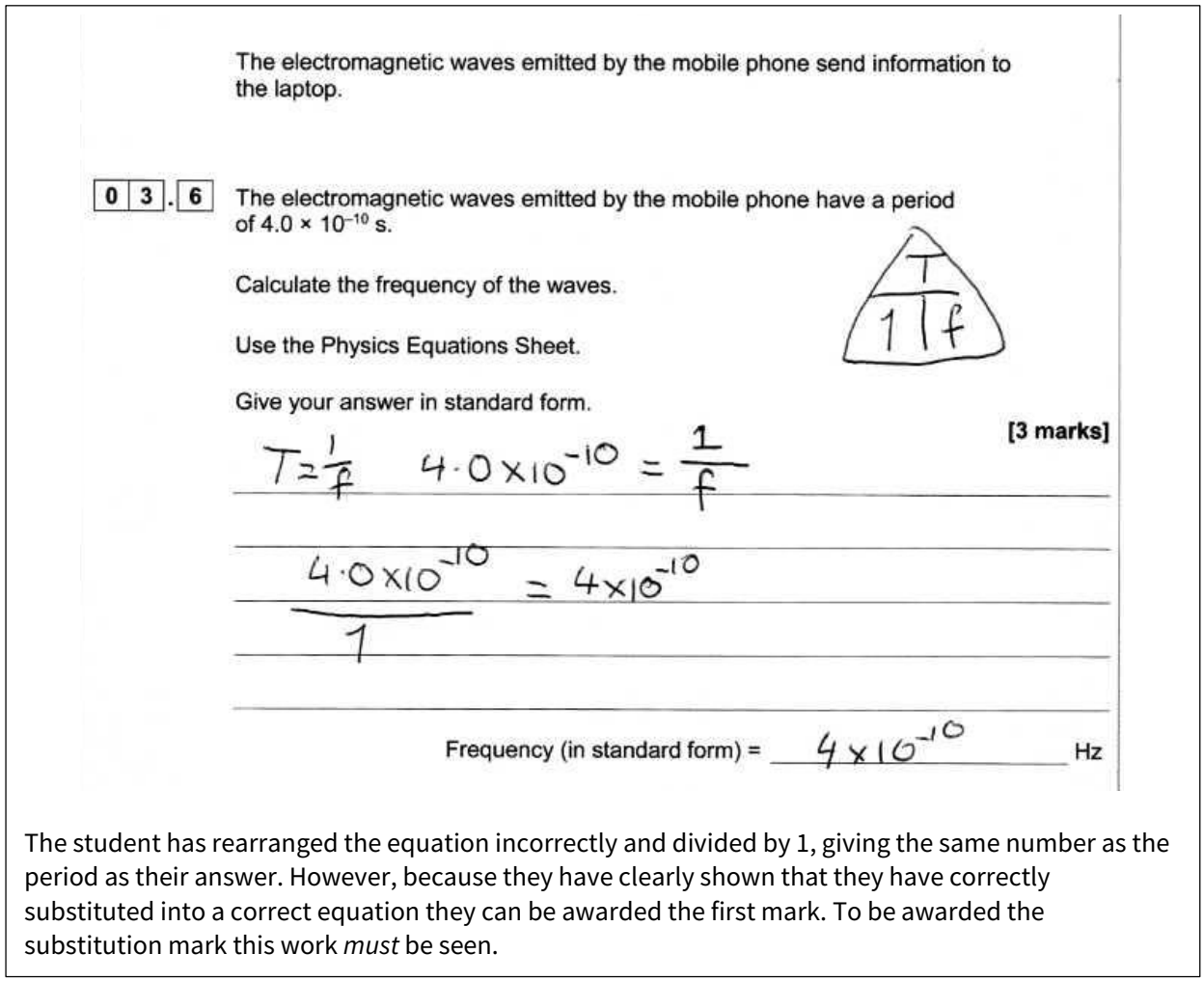
6.6.1.2 Properties of waves

Answer 12 · Examiner comments June 2024 | 8464/P/2H | Original Q3

03.4 Just over 25% of students gave the correct colour for the shortest wavelength of visible light. Most of those that gained the mark did write violet but some stated purple, which was allowed. The most common incorrect answer was red, but a wide range of colours was given, including black and white.

03.5 Nearly 75% of students gained at least 1 mark for giving a risk, although less than 20% of students listed the three groups and correctly linked each to a specific risk such as UV causes skin cancer. Most of the 1-mark answers gained the compensation mark for stating that high-frequency electromagnetic waves cause cancer.

03.6 This question required students to manipulate numbers in standard form and 60% of students gained all 3 marks. The equation is relatively simple as it contains only two variables. However, this seemed to throw some students, who substituted correctly but then rearranged incorrectly and multiplied the period by one, so gave their final answer as the same number as the period. Approximately 10% of students inputted the power of ten incorrectly into their calculators; these students were, however, still able to score 2 marks.



The electromagnetic waves emitted by the mobile phone send information to the laptop.

0 3 . 6 The electromagnetic waves emitted by the mobile phone have a period of 4.0×10^{-10} s.

Calculate the frequency of the waves.

Use the Physics Equations Sheet.

Give your answer in standard form.

[3 marks]

$T = \frac{1}{f}$ $4.0 \times 10^{-10} = \frac{1}{f}$

$\frac{4.0 \times 10^{-10}}{1} = 4 \times 10^{-10}$

Frequency (in standard form) = 4×10^{-10} Hz

The student has rearranged the equation incorrectly and divided by 1, giving the same number as the period as their answer. However, because they have clearly shown that they have correctly substituted into a correct equation they can be awarded the first mark. To be awarded the substitution mark this work *must* be seen.

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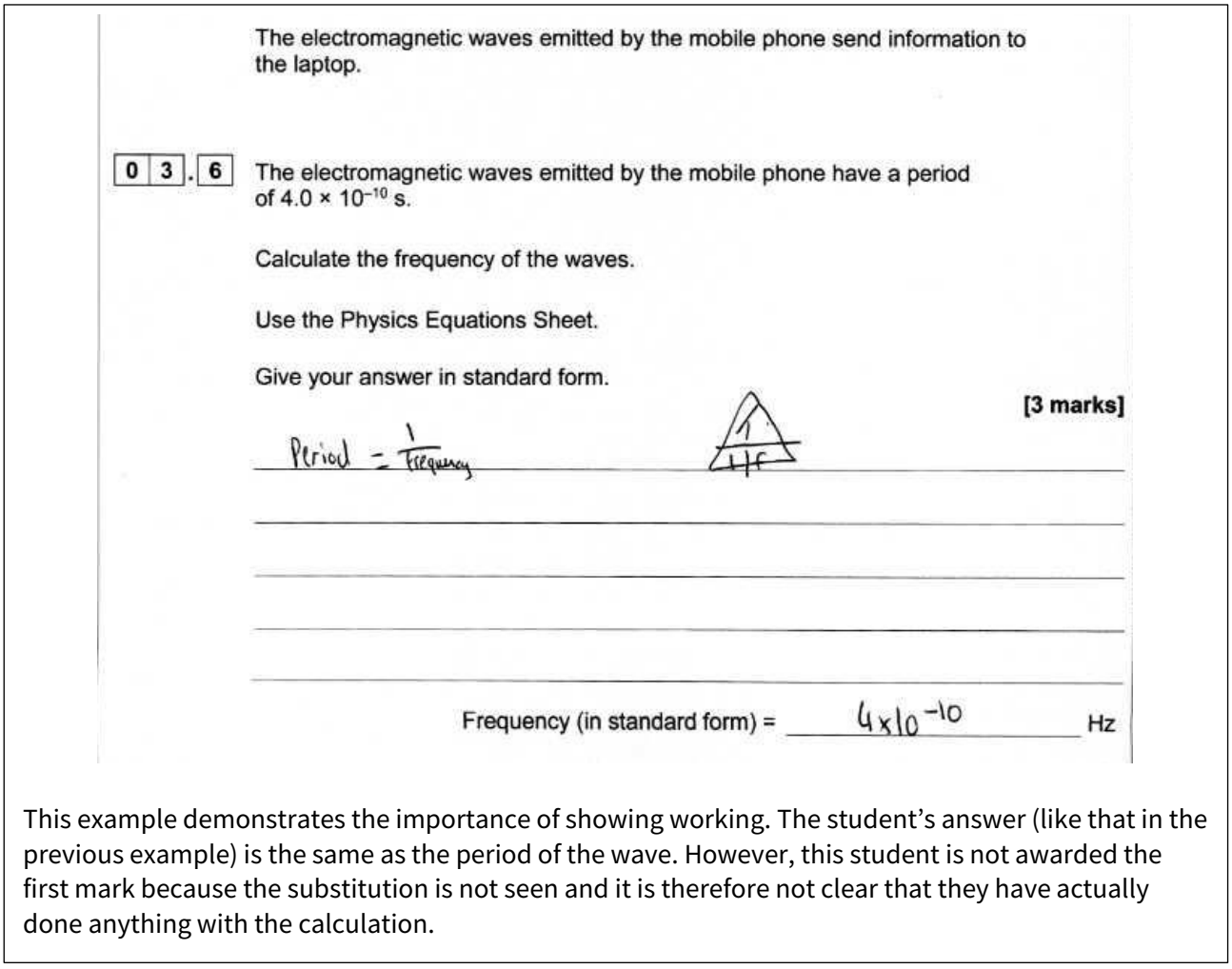
6.6.1.2 Properties of waves

Answer 12 · Examiner comments June 2024 | 8464/P/2H | Original Q3



The electromagnetic waves emitted by the mobile phone send information to the laptop.

0 3 . 6 The electromagnetic waves emitted by the mobile phone have a period of 4.0×10^{-10} s.

Calculate the frequency of the waves.

Use the Physics Equations Sheet.

Give your answer in standard form.

[3 marks]

Period = 1 / Frequency

1 / Hz

Frequency (in standard form) = 4×10^{-10} Hz

This example demonstrates the importance of showing working. The student's answer (like that in the previous example) is the same as the period of the wave. However, this student is not awarded the first mark because the substitution is not seen and it is therefore not clear that they have actually done anything with the calculation.

03.7 The concepts being assessed in this high-demand question are very abstract and complex. Some students had obviously learnt this and wrote excellent explanations. 10% of students scored more than 1 mark.

Answer 13 · Examiner comments

June 2025 | 8464/P/1H | Original Q5

Question 5 (Standard/high and high demand)

05.1 55% of students gave one correct value and 20% gave both correct. Where, only one was correct, the frequency was more commonly known.

05.2 75% of students correctly named both wires and the correct colour of insulation. Where only one mark was awarded, it was most common to see the live wire and colour correct, but the name of the second wire was incorrect. Incorrect responses often gave the colour of the earth wire.

05.3 43% gained 1 mark. The vast majority of these were awarded the mark for direct (potential difference) is always in the same direction. Under 10% of students also gained the mark for the alternating potential difference. For alternating potential difference, the idea that it is continuously changing direction must be explicit.

0 5 . 3 The input to the charger is an alternating potential difference.

The output from the charger is a direct potential difference.

Describe the difference between an alternating potential difference and a direct potential difference.

[2 marks]

Direct potential difference only goes in one direction whereas alternating potential difference goes in more than one direction

This answer gains 1 mark. For alternating potential difference, 'more than one direction' is insufficient.

0 5 . 3 The input to the charger is an alternating potential difference.

The output from the charger is a direct potential difference.

Describe the difference between an alternating potential difference and a direct potential difference.

[2 marks]

Alternating potential difference constantly changes direction but direct potential difference goes in one direction only.

This answer gains 2 marks; the idea that an alternating potential difference is continuously changing direction is explicit, along with a correct description of direct potential difference.

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6.6.1.2 Properties of waves

Answer 13 · Examiner comments June 2025 | 8464/P/1H | Original Q5

05.4 60% of students correctly identified that the laptop is using energy as it is still being used. Only a very small number correctly explained that this meant that the rate at which the energy is stored in the battery decreases.

05.5 This multi-step calculation proved to be more challenging than in previous years. Only approximately 15% of students gained full marks. 50% of students calculated the power of the laptop but could not get any further. Some students calculated the time in seconds correctly but could not convert the answer to hours. Students are reminded that they should show their working for multi-step calculations.

Answer 14 · Examiner comments

Question 3 (Standard, standard/high and high demand)

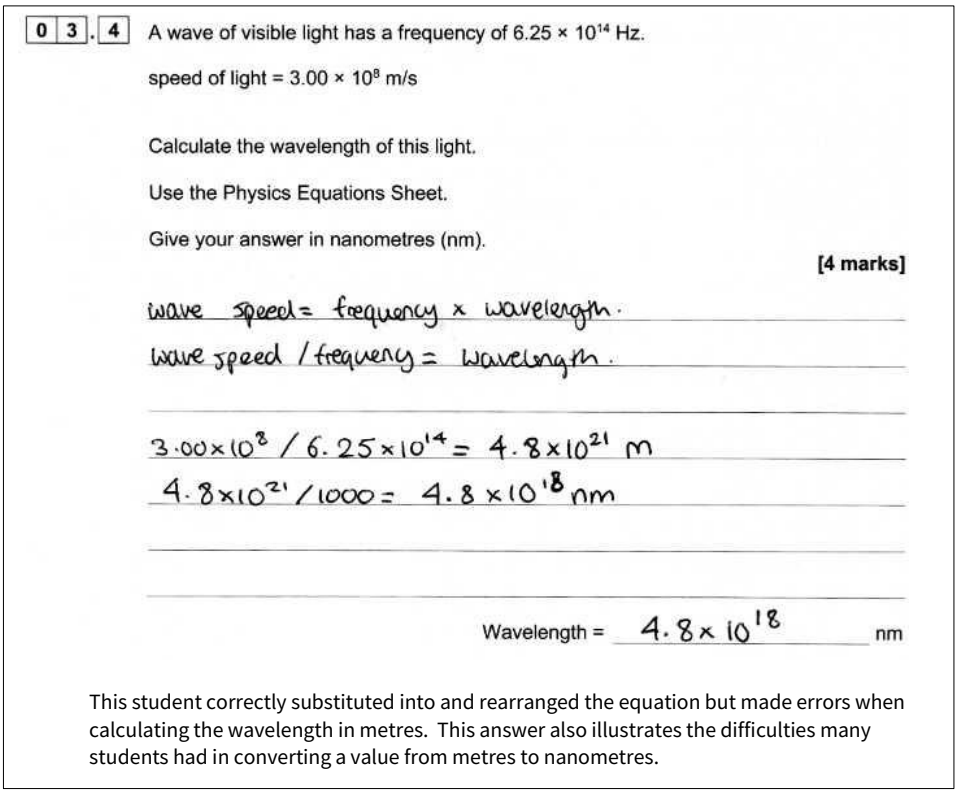
03.1 About a quarter of students were able to give a complete and correct definition of a transverse wave, with just under a fifth giving a definition that gained partial credit.

03.2 Nearly two thirds were able to give another risk caused by exposure to ultraviolet.

03.3 Just over 60% identified that ultraviolet has a shorter wavelength than visible light.

03.4 Giving an answer in nm proved to be very challenging, with just under 10% managing to work out the correct final answer.

A surprisingly large proportion of students struggled to calculate the correct power of ten to their answer, with working such as $\frac{3\times10^{8}\ \text{m/s}}{6.25\times10^{14}\ \text{Hz}} = 4.8\times10^{21}\ \text{m}$ being relatively common. Students who did this could then go on to convert their calculated value into nm and gain the final mark, but it was very common for students to multiply their answer by 10^{-9} instead of dividing by 10^{-9}, so the final mark was not often gained. Many students who attempted the conversion to nm thought that nano referred to 10^{-3} or 10^{-6}.



0 3 . 4 A wave of visible light has a frequency of 6.25×10^{14} Hz.

speed of light = 3.00×10^{8} m/s

Calculate the wavelength of this light.

Use the Physics Equations Sheet.

Give your answer in nanometres (nm).

[4 marks]

wave speed = frequency x wavelength.

wave speed / frequency = wavelength.

$3.00\times10^{8} / 6.25\times10^{14} = 4.8\times10^{21}$ m

$4.8\times10^{21} / 1000 = 4.8\times10^{18}$ nm

Wavelength = 4.8×10^{18} nm

This student correctly substituted into and rearranged the equation but made errors when calculating the wavelength in metres. This answer also illustrates the difficulties many students had in converting a value from metres to nanometres.

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6.6.1.2 Properties of waves

Answer 14 · Examiner comments

June 2025 | 8464/P/2H | Original Q3

03.5 Students struggled to explain why refraction occurs using the idea of wavefronts. It was very common for students to refer to the density of the glass, and sometimes to optical density. All of these references were ignored. Some students recalled that the wave speed changes but did not make it clear whether they thought the waves were increasing or decreasing in speed, so did not score any marks. Only about a fifth of students gained any credit in this question.

03.6 About four in ten students gained at least one mark, with approximately 20% giving a fully correct answer. The refracted rays drawn were in many different directions, but those who were able to draw the ray in the correct direction usually did so with accuracy and gained the second mark, and those that did not score the second mark tended to draw their refracted rays in completely the wrong direction. Some students gained the mark for drawing the refracted ray without having drawn a normal.

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