

## Mark Scheme

Q1.

Question Number	Answer	Mark
(i)	<p><b>D refraction is the only correct answer</b></p> <p><i>A 'deflection' is an incorrect distracting description</i></p> <p><i>B 'incidence' is incorrect, that would be angle X</i></p> <p><i>C 'reflection' is incorrect, no reflection being shown in the diagram</i></p>	<p><b>(1)</b></p> <p>AO 1 1</p>

Question Number	Answer	Additional guidance	Mark
(ii)	<p>any pair of coordinates selected from the line (1)</p> <p>in range → 0.6(0) to 0.7(0) (1)</p>	<p>e.g. 20 and (13 or 14) or 10 and (6 or 7)</p> <p>ignore any units given</p> <p>award full marks for a correct answer without working</p>	<p><b>(2)</b></p> <p>AO 2 1</p>

Question Number	Answer	Additional guidance	Mark
(iii)	<p>an explanation linking:</p> <p>repeat (1)</p> <p>different angles / more values of X (1)</p> <p>for larger angles / values of X (1)</p>	<p>allow 'more measurements' / 'repeat experiment' / collect more data</p> <p>&gt; 20°</p>	<p><b>(3)</b></p> <p>AO 3 3a</p>

Q2.

Question Number	Answer	Additional guidance	Mark
	(Jupiter is) 5 times (further away) (1)  radio waves and light waves travel at the same speed (in space) (1)	All electromagnetic (EM) waves travel at the same speed  accept attempt to use consistent speed (of light) to calculate two distances	<b>(2)</b>

Q3.

Question Number	Answer	Mark
	<p>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.</p> <p>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.</p>	<b>(6) exp</b>

	<b>AO1 strand 1 (6 marks)</b>	
	<ul style="list-style-type: none"> <li>• radio waves are (often) produced intentionally (by humans)</li> <li>• gamma rays are (often) produced spontaneously / randomly</li> <li>• radio waves are produced by (free) electrons</li> <li>• radio waves are produced by oscillating (free) electrons / alternating current (ac)</li> <li>• radio waves are produced in electrical circuits / aerials</li> <li>• gamma rays may result from radioactive decay</li> <li>• gamma rays produced in the nucleus</li> <li>• gamma rays produced by energy changes / rearrangement in the nucleus</li> <li>• gamma rays produced to stabilise the nucleus</li> <li>• gamma rays produced in annihilations (PET scanning etc)</li> <li>• gamma rays may be produced as a result of (nuclear) fission or fusion</li> </ul>	

Level	Mark	Descriptor
	0	<ul style="list-style-type: none"> <li>• No rewardable material.</li> </ul>
Level 1	1-2	<ul style="list-style-type: none"> <li>• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1)</li> <li>• Presents an explanation with some structure and coherence. (AO1)</li> </ul>
Level 2	3-4	<ul style="list-style-type: none"> <li>• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1)</li> <li>• Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)</li> </ul>
Level 3	5-6	<ul style="list-style-type: none"> <li>• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1)</li> <li>• Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)</li> </ul>

Summary for guidance			
Level	Mark	Additional Guidance	General additional guidance – the decision within levels
	0	No rewardable material.	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.
Level 1	1–2	<u>Additional guidance</u>  isolated fact(s) about one radiation	<u>Possible candidate responses</u>  gamma rays are (often) produced spontaneously / randomly
Level 2	3–4	<u>Additional guidance</u>  Some understanding shown i.e. a limited comparison made including some facts about the production of each radiation  OR more detailed facts given about the production of one of them	<u>Possible candidate responses</u>  radio waves produced in wires and gamma produced in nucleus  radio waves produced by AC in wires

Level 3	5–6	<u>Additional guidance</u>  Understanding is detailed and fully developed.  detailed comparison made with linked facts about the production of each  (one radiation may have significantly more detail than the other but both should feature for level 3)	<u>Possible candidate responses</u>  radio waves produced by electrons oscillating in wires; gamma produced by annihilation of electrons interacting with positrons
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Question number	Indicative content	Mark
	<p>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.</p> <p>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.</p> <p style="text-align: center;">AO1</p> <p><b>Comparison</b>  X-rays: high frequency / short wavelength / ionising / high energy  Radio waves: low frequency / long wavelength / not ionising / low energy</p> <p><b>X ray are used</b></p> <ul style="list-style-type: none"> <li>• in medical diagnosis, to find broken bones, damage to lungs</li> <li>• radiotherapy</li> <li>• treatment of cancer</li> <li>• airport security</li> <li>• revealing counterfeit art</li> </ul>	<b>(6)</b> <b>AO1</b>

	<p><b>X-rays are emitted when electrons change energy levels because</b></p> <ul style="list-style-type: none"> <li>• electrons in lower energy levels can absorb energy</li> <li>• the electrons move to higher energy levels</li> <li>• when the electrons return to a lower energy level</li> <li>• the electrons lose energy as radiation.</li> <li>• the electrons need to lose a large amount of energy</li> <li>• (so that) they emit x-ray radiation of high energy/frequency</li> <li>•</li> </ul> <p><b>Radio waves are used</b></p> <ul style="list-style-type: none"> <li>• broadcasting television</li> <li>• broadcasting radio</li> <li>• communications</li> <li>• satellite transmissions</li> <li>• mobile phones</li> <li>• radar</li> </ul>	
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	<p><b>Radio-waves are emitted when</b></p> <ul style="list-style-type: none"> <li>• electrons oscillate in electrical circuits</li> </ul> <p><b>oscillations are</b></p> <ul style="list-style-type: none"> <li>• current (flow of electrons) that continually change direction</li> <li>• current flows up and down in a (transmitting) aerial</li> <li>• alternating current (AC)</li> <li>• this generates radio waves in the air around the aerial</li> <li>• the frequency of the radio waves corresponds to the oscillation frequency</li> </ul> <p><b>N.B. No credit is given for: Electrons within an atom go through energy changes OR Radio waves are produced in electrons in circuits These phrases are in the stem of the question</b></p>	
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Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1)  Presents a description which is not logically ordered and with significant gaps. (AO1)
Level 2	3-4	Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1)  Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1)
Level 3	5-6	Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures 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 decisions 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 bottom of that level
	0	No rewardable material	
Level 1	1-2	<u>Additional guidance</u>  Elements of physics present i.e. isolated knowledge of principles, two unconnected statements	<u>Possible candidate response</u>  any use of X rays  any use of radio waves  any comparison  electrons are around the nucleus  a current is electrons (moving)  electrons oscillate
Level 2	3-4	<u>Additional guidance</u>  Some knowledge of principles with limited detail on use and a comparison or process	<u>Possible candidate response</u>  any use of x-rays and of radio waves with limited detail  and one of:  a comparison  or  electrons lose energy to emit X-rays  or  electrons oscillate in circuits

Level 3	5-6	<u>Additional guidance</u>  Detailed knowledge of principles on use with logical connections made about one process	<u>Possible candidate response</u>  Use of X-rays and of radio waves with detail  and one of:  electrons lose energy to change to lower energy level and emit energy as X-rays  or  electrons oscillate in circuit and currents move up and down in aerials to generate radio waves
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Question Number	Answer	Additional guidance	Mark									
	<p>a description including:</p> <p>UVA <b>mostly</b> transmitted OR <b>some</b> absorbed (1)</p> <p>UVB <b>some</b> transmitted OR <b>mostly</b> absorbed (1)</p> <p>UVC <b>not</b> transmitted OR <b>mostly</b> absorbed OR <b>some</b> reflected (1)</p> <p>correct relationship of absorption/ transmission to wavelength / <math>\lambda</math> (1)</p>	<p>UVA <b>mostly</b> travels through</p> <p>accept <b>less</b> transmitted than UVA</p> <p><b>more</b> absorbed than UVA or UVB</p> <p>wavelength decreasing (with) absorption increasing OR longer wavelengths transmit more</p> <table border="1"> <tr> <td><math>\lambda</math></td> <td>abs</td> <td>trans</td> </tr> <tr> <td>inc</td> <td>dec</td> <td>inc</td> </tr> <tr> <td>dec</td> <td>inc</td> <td>dec</td> </tr> </table>	$\lambda$	abs	trans	inc	dec	inc	dec	inc	dec	(4)
$\lambda$	abs	trans										
inc	dec	inc										
dec	inc	dec										

Q6.

Question number	Answer	Additional guidance	Mark
	<p>A description including two from:</p> <p>trace / mark where the ray went into and out of( through) the glass block / line on either side of glass block(1)</p> <p>(remove block) join entry and exit points (of ray of light) (1)</p> <p>use the protractor to measure the angle between the refracted/drawn ray and the normal (1)</p>	<p>accept 90° line etc.</p>	(2)



Q7.

Question number	Answer	Additional guidance	Mark
(i)	curve through origin, through all points - by eye (1)	<p>Figure 6</p>	(1) AO1

Question number	Answer	Additional guidance	Mark
(ii)	$(r =) 42(^{\circ}) \pm 2(^{\circ})$ (1)	ECF their graph	(1) AO3

Question number	Answer	Additional guidance	Mark
(iii)	<p>Description to include two from:</p> <p><math>r</math> increases as <math>i</math> increases (1)</p> <p>(but) not in proportion (1)</p> <p>increase in <math>r</math> becomes less (for same increase in <math>i</math>) (1)</p>	<p><math>r</math> increases as <math>i</math> increases</p> <p>(but) not in even steps/not straight line/non-linear/gradient changes</p> <p><math>r</math> always less than <math>i</math></p>	(2) AO3

Q8.

Question number	Answer	Additional guidance	Mark
	<p>An explanation that makes reference to: identification – knowledge (1 mark) and reasoning /justification – knowledge (1 mark):</p> <ul style="list-style-type: none"> <li>the wavelength decreases because wavelength is the ratio of wave velocity to frequency (1)</li> <li>and the wave velocity reduces at the boundary but the frequency remains the same (1)</li> </ul>	<p>allow the same number of waves per second arrive at the boundary as leave it for no change in frequency at the boundary</p>	<b>(2)</b>

Q9.

Question number	Answer	Additional guidance	Mark
	<p>Explanation linking <b>three</b> from:</p> <p>(some) light is <u>reflected</u> (1)</p> <p>(at) the top edge (1)</p> <p>(some) light is <u>absorbed</u> (1)</p> <p>by the glass (1)</p>	<p>in the air</p> <p>in the (glass) block</p> <p>credit responses in terms of attenuation/dispersion/reflection at the second face/spreading out</p>	<b>(3)</b> <b>AO2</b>

Q10.

Question number	Answer	Additional guidance	Mark
	<p>explanation linking two from:</p> <p>(damage to) cell(s) (1)</p> <p>(because gamma rays are) ionising / high frequency/very energetic (1)</p> <p>(causing / curing/diagnosing) cancer / mutation / chromosomal damage / dna damage/burns (1)</p>	(rapid/unwanted) division of cells	(2)

Q11.

Question number	Answer	Additional guidance	Mark
	<p>explanation linking:</p> <p>wave P refracts (towards the normal) (1)</p> <p>because P slows down (1)</p> <p>AND</p> <p>wave Q is reflected (at an equal angle from the boundary) (1)</p> <p>without change of speed of Q (1)</p>	<p>accept 'upper layer' for 'P'</p> <p>accept 'wavelength decreases'</p> <p>accept 'bends' for 'refracts' in this instance</p> <p>accept 'lower layer' for 'Q'</p> <p>accept 'wavelength unchanged'</p> <p>accept 'wave Q bounces off' (at an equal angle)</p> <p>allow one mark for refraction and reflection if no other mark awarded</p>	(4)

Q12.

Question Number	Answer	Additional guidance	Mark
	<p>an explanation linking:</p> <p>infrared is absorbed / blocked (by the armchair / objects) / cannot pass through</p> <p><b>OR</b></p> <p>radio waves can go through (the armchair/objects) (1)</p> <p><b>WITH</b></p> <p>(infrared and radio have) different wavelengths / frequencies</p> <p>OR infrared requires 'line-of-sight' (idea)</p> <p>OR radio waves do not require 'line-of-sight' (idea)</p> <p>OR diffraction (idea)</p> <p>(1)</p>	<p>stopped</p> <p>transmitted</p> <p>accept comparison</p>	(2)

Q13.

	Answer	Additional guidance	Mark
	<p>An explanation linking <b>two</b> from:</p> <p>to preserve food (1)</p> <p>by 'killing' bacteria (1)</p> <p>(gamma) is (very) penetrating (and so reaches all the food). (1)</p> <p>sterilising (1)</p>	<p>stop food going off</p>	(2) AO2

Q14.

Question Number	Answer	Mark
	<p><b>B</b> frequency increases</p> <p><i>A is not correct because the danger does not increase with decreasing frequency</i></p> <p><i>C is not correct because all waves in the e-m spectrum have the same velocity</i></p> <p><i>D is not correct because all waves in the e-m spectrum have the same velocity</i></p>	<p><b>(1)</b> <b>AO1</b></p>

Q15.

Question number	Answer	Mark						
	<table border="1"> <thead> <tr> <th></th> <th>wave velocity</th> <th>wavelength</th> </tr> </thead> <tbody> <tr> <td>[x] A</td> <td>decreases</td> <td>decreases</td> </tr> </tbody> </table> <p>B is not correct because the wavelength does not increase C and are not correct because the wave velocity does not increase</p>		wave velocity	wavelength	[x] A	decreases	decreases	<p><b>(1)</b> <b>AO1</b></p>
	wave velocity	wavelength						
[x] A	decreases	decreases						

Q16.

Question number	Answer	Additional guidance	Mark
	D a TV remote control		<b>(1)</b>

Q17.

Question number	Answer	Additional guidance	Mark
	<p>An answer that combines the following points of understanding to provide a logical description:</p> <ul style="list-style-type: none"><li>• radio waves will not reach the satellites (from Earth) / be received (on Earth) from the satellites (1)</li><li>• because they are reflected by the atmosphere (1)</li></ul>	<p>ORA for microwaves</p> <p>reflected by ionosphere / before reaching satellite</p>	<p>(2)</p>

Q18.

Question Number	Answer	Additional guidance	Mark
	<p>an explanation linking:</p> <p>(the colours have) different wavelengths (1)</p> <p>different wavelengths / colours travel at different speeds (1)</p> <p>so refract by different amounts (1)</p>	<p>allow the word frequencies for wavelengths</p> <p>for refract allow bend/change direction/follow different path</p>	<p>(3)</p> <p>AO 2 1</p>

Q19.

Question number	Answer	Mark
(i)	<p>Any three of</p> <ul style="list-style-type: none"> <li>• sound waves are longitudinal but radio waves are transverse.</li> <li>• sound waves need a medium but radio waves travel through a vacuum.</li> <li>• sound waves have (much) lower velocity than radio waves.</li> <li>• sound waves have lower frequency / greater wavelength than radio waves</li> <li>• sound waves are vibrations but radio waves are electromagnetic waves.</li> </ul>	(3)

Q20.

Question Number	Answer	Additional guidance	Mark
	<p>suggestion to include <b>one</b> from</p> <p>(ultraviolet/UV) is (the most) harmful to the eyes (1)</p> <p>protects eyes from damage/harm (from UV rays) (1)</p>	<p>(UV) can damage eyes</p> <p>protects against cataracts/cancer</p> <p>accept makes it more comfortable in bright sunlight</p>	(1)

Q21.

Question number	Answer	Acceptable	Mark
(i)	<p>An explanation that combines identification - understanding (1 mark) and reasoning/justification - understanding (2 marks):</p> <ul style="list-style-type: none"> <li>white light is a mixture of different wavelengths (1)</li> <li>each wavelength / colour is refracted by a different amount (1)</li> <li>short <u>wavelengths</u> are refracted more / ORA (1)</li> </ul>	ignore colours	(3)

Question number	Answer	Acceptable	Mark
(ii)	<p>An answer that combines the following points to provide a logical description of the method:</p> <ul style="list-style-type: none"> <li>Place a thermometer (with blackened bulb) beyond position of red light (1)</li> <li>Look for rise in temperature (measured by thermometer) (1)</li> </ul>		(2)

Q22.

Question Number	Answer	Acceptable answers	Mark
(a)	D an ultraviolet wave		(1)

Question Number	Answer	Acceptable answers	Mark
(b)	<p>Ultraviolet (from lamp) <u>absorbed</u> (by fluorescent substance/bank note) (1)</p> <p>(which) emits {visible/light} (into eye) (1)</p>	<p>Allow UV for ultraviolet Allow 'taken in' for absorbed</p> <p>Allow 'given out'/releases/fluoresces for emits 'Fluoresces' on its own is insufficient</p> <p>Mention of both ultraviolet AND visible/light only, scores 1 mark only</p>	(2)



