Question Number	Answer	Acceptable answers	Mark
1(a)(i)	☒ **B** 2.5 ÷ 4		**(1)**

Question Number	Answer	Acceptable answers	Mark
1(a)(ii)	either P = 2.5 x 0.2 or 2.5 = P / 0.2 (1) 0.5 (W) (1)	give full marks for correct answer, no working	**(2)**

Question Number	Answer	Acceptable answers	Mark
1(b)(i)	3.0 +/- 0.5 (cm)		**(1)**

Question Number	Answer	Acceptable answers	Mark
1(b)(ii)	an explanation linking • 2 MHz (1) and any **one** from: • has a higher intensity inside tissue (1) • less energy absorbed (1) • less attenuation (1) • penetrates furthest /deepest (1)	this frequency alone RA loses intensity more gradually highest penetration accept "2MHz and 4MHz" with correct reason for 1 mark	**(2)**

Question Number			Mark
QWC	*)	A comparison of endoscopes with any one of the following devices: **Diagnostic devices** • CAT scanners • Fluoroscopes • Thermal imagers / IR thermometers • Pulse oximeters • PET scanners • X-ray machines • Gamma cameras **Link to electromagnetic radiation** • Endoscopes use TIR of light in optical fibres • CAT scanners X- rays and computer to generate 3D images • Fluoroscopes use X- rays and a video camera • Thermal imagers use infrared emitted by a body • IR / red LEDs used to measure oxygen levels • PET scanners detect radiation emitted by electron-positron annihilation • Gamma cameras detect gamma rays from radioactive sources **Other factors for comparison** • Safety • Ease of use • Frequency / wave length • Intensity • Penetration • Ionising / non-ionising	**(6)**
Level	**0**	No rewardable content	
1	**1 - 2**	• a limited comparison between an endoscope and one device e.g. endoscopes use light and CAT scanners detect broken bones • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy	
2	**3 - 4**	• a simple comparison between an endoscope and one device, linking them to the electromagnetic radiation used for both and a detail of use for one of them e.g. endoscopes use visible light to examine internal organs and CAT scans use X-rays • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy	
3	**5 - 6**	• a detailed comparison between an endoscope and one device, linking them to the electromagnetic radiation used for both and a detail of use for both of them e.g. endoscopes use visible light which is passed down optical fibres by TIR to examine internal organs. Fluoroscopes use X-rays and a video camera to show positioning of stents in arteries. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately elling, punctuation and grammar are used with few errors	

Question Number	Answer	Acceptable answers	Mark
2(a)	**A** all the time		**(1)**

Question Number	Answer	Mark
2(b)	<table><tr><th>radiation</th><th>type</th><th>transfer</th></tr><tr><td>alpha</td><td>particle</td><td>energy</td></tr><tr><td>beta</td><td>particle (1)</td><td>energy</td></tr><tr><td>gamma</td><td>wave (1)</td><td>energy (1)</td></tr></table> 2 words in 1 box scores 0 for that box	**(3)**

Question Number	Answer	Acceptable answers	Mark
2(c)	Any **two** from the following points • sterilising food (1) • sterilising medical equipment(1) • detection of cancer(1) • treatment of cancer(1)	cleaning water PET scan gamma camera Radiotherapy Industrial uses eg Measuring thickness Tracers (Gamma) telescopes	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(d)	A description including the following points • travel at the same speed (1) • in a vacuum/space (1)		**(2)**

Question Number	Answer	Acceptable answers	Mark
3(a)(i)	**A** infrared and microwaves		**(1)**

Question Number	Answer	Acceptable answers	Mark
3(a)(ii)	**C** lower frequency than ultraviolet		**(1)**

Question Number	Answer	Acceptable answers	Mark
3(b)(i)	A description including **two** of the following points **Either** • UV penetrates the skin / can damage normal cells/ cause cell mutation/ionise cells (1) • can cause (skin) cancer / can cause premature ageing (1) **OR** • UV penetrates the eye / can damage/mutate cells in the eye (1) • can cause cataracts / damage to the retina (macular degeneration) (1)	Ignore "harm" or "harmful" Accept "tissue" for cells sunburn can cause (snow) blindness	**(2)**

Question Number	Answer	Acceptable answers	Mark
3(b)(ii)	An explanation linking two of the following points • (ultraviolet/it) has a higher frequency (than infrared) (1) • (therefore ultraviolet/it) has higher (photon) energy (1) • (ultraviolet/it) penetrates further /(ultraviolet/it) causes ionisation (1)	Accept reverse argument if clearly about IR has a shorter wavelength	**(2)**

Question Number		Indicative content	Mark
QWC	***3(c)**	A comparison including some of the following points **Similarities** • used white light from the Sun • glass prism • produced a visible spectrum **(Herschel's) infrared experiment** • used a thermometer to measure the temperature of different colours of the visible spectrum • temperature increased towards the red end • temperature increased more past the red end of the spectrum. • temperature rise was due to invisible rays named infrared **(Ritter's) ultraviolet experiment** • used silver chloride on paper this slowly turns black in visible light. • silver chloride turned black faster as the paper was put at the violet end of the spectrum • beyond the violet the silver chloride turned black even more rapidly • due to the presence of invisible rays (originally called chemical rays) now called ultraviolet	**(6)**

Level	**0**	no rewardable material
1	**1 -2**	• a limited description of **either** experiment including two or more basic points (written or shown on a labelled diagram) e.g. prism is made of glass; the colours of the spectrum are ROYGBIV OR (Herschel's) experiment discovered IR; he measured the temperature of the spectrum OR (Ritter) put sensitive (silver chloride) paper at different places in the spectrum; (Ritter's) experiment discovered UV • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	**3 -4**	• a simple description of **either** experiment including a statement linking two ideas **and** a point of similarity **or** difference with the other experiment e.g. (Herschel) moved a thermometer beyond the red end of the spectrum and the temperature increased **and** both (Herschel's and Ritter's) experiments use a prism to produce the spectrum (NB this last point could be shown in a labelled diagram) OR The sensitive paper that (Ritter) used turns black in visible light and it turns black quicker when moved beyond the violet end of the spectrum **and** (Ritter's) experiment shows ultraviolet rays but (Herschel's) experiment shows infrared rays (NB this last point could also be shown in a labelled diagram) • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	**5 -6**	• A detailed description including statements about each experiment that link ideas to show a point of similarity **AND** a point of difference e.g. (Herschel) measured the temperature of the colours and discovered a higher temperature beyond the red end **and** (Ritter) used sensitive (silver chloride) paper that turned black very quickly when moved beyond the violet end of the spectrum **and** both experiments use a prism to separate the colours of the spectrum **and** (Herschel's) experiment uses a thermometer instead of sensitive paper (already stated) • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

<table>
<tr><th>Question Number</th><th>Answer</th><th>Acceptable answers</th><th>Mark</th></tr>
<tr><td>4(a)(i)</td><td>

infrared (1)
radio waves (1)
2 marks if both correct i.e.

<table>
<tr><td>gamma rays</td><td>X-rays</td><td>ultraviolet</td><td>visible light</td><td>infrared /IR</td><td>microwaves</td><td>radio (waves)</td></tr>
</table>

1 mark for one correct
1 mark if answers interchanged i.e.

<table>
<tr><td>gamma rays</td><td>X-rays</td><td>ultraviolet</td><td>visible light</td><td>radio (waves)</td><td>microwaves</td><td>infrared /IR</td></tr>
</table>
</td><td></td><td>(2)</td></tr>
</table>

Question Number	Answer	Acceptable answers	Mark
4(a)(ii)	gamma (rays)	or symbol for gamma e.g. γ	**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b)(i)	A description linking **one** of the following pairs • on items (1) • assist in identification (if stolen) (1) • on document/currency (1) • help to identify forgery (1) • write (on paper) (1) • secret message (1) • stamp / on (back of) hand (1) • as pass out for an event (1)	• named item • to identify (owner) • banknotes eq (1) • (to identify) genuine notes/forgeries (1) • write (message /note)(1) • (that) other people cannot see(1) • (print on) t-shirt (1) • shows up in club (1) **Allow** to detect UV (radiation) for 1mark **Ignore** uv light uses not on ink, e.g. forensic use on blood/ use in the dark (as it glows)/ etc.	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(b)(ii)	causes damage to (unprotected) eyes/skin/DNA/ cells (1)	blindness /(skin) cancer/(sun)burn (to skin)/mutations	**(1)**

Question Number	Answer		Mark
4(c)	A description linking **one** of the following pairs	statement of recognised application detail of how it works/ how it is used	
	• (at the) airport /customs / docks / security checks (1) • for dangerous/illegal items (1)	• to scan {luggage / people/ vehicles} (1) • (check) for things that are not meant to be there e.g. liquids, knives, guns, explosives, drugs etc (1)	
	• checking welds (1)	checking pipes/engines/aircraft/structures etc	
	• to examine under the surface (1)	for cracks	
	• checking paintings eq (1) • to look for detail under the top paint layer (1)	**IGNORE** idea of X-ray vision	
	• X-ray telescopes/astronomy • to study/look at objects in space	e.g. stars/ galaxies/ space/black holes/neutron stars/planets	
	• check packaging e.g. cans/packets • (to see if) filled to correct level	for 'foreign' objects	
	• sterilising (1) • food/hospital equipment (1)	killing bacteria **NOT** to scan (the body) for broken bones	**(2)**