

Mark Scheme

Q1.

Question number	Answer	Notes	Marks
(a)	An arrow drawn from left to right by eye;		1
(b)	Comparative statements for side containing A: Wavefronts closer together/EQ; (therefore) wavelength smaller; Same speed; ($v = f \times \lambda$ so) frequency larger;	Allow RA for B Allow e.g. "waves more compressed together" Condone mention of the Doppler effect for 1 mark if no other mark scored.	4

Q2.

Question number	Answer	Notes	Marks
(a) (i)	C (sound waves); A is incorrect because it is a transverse wave B is incorrect because it is a transverse wave D is incorrect because it is a transverse wave		1
(ii)	one mark for each correct line;; Electromagnetic wave <div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;"> <div style="border: 1px solid black; padding: 2px; margin-bottom: 10px;">microwave</div> <div style="border: 1px solid black; padding: 2px;">infrared</div> </div> <div style="text-align: center;"> <div style="border: 1px solid black; padding: 2px; margin-bottom: 10px;">skin burns</div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 10px;">blindness</div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 10px;">internal heating of body tissue</div> <div style="border: 1px solid black; padding: 2px;">cell mutation</div> </div> </div>	two lines from any left hand box is a contradiction and scores zero for that box	2
(b) (i)	A (checking for broken bones); B is incorrect because microwaves and infrared have this use C is incorrect because ultraviolet has this use D is incorrect because alpha radiation has this use		1
(ii)	B (cooking food); A is incorrect because x-rays has this use C is incorrect because ultraviolet has this use D is incorrect because gamma has this use		1

Q3.

Question number	Answer	Additional guidance	Mark
(a)(i)	wave speed = frequency × wavelength	equation can be given in words or symbols	1

Question number	Answer	Additional guidance	Mark
(a)(ii)	<ul style="list-style-type: none"> • Conversion of kHz to Hz OR cm to m • Substitution • Evaluation <p>e.g. $2.9 \text{ kHz} = 2900 \text{ Hz}$ (1) $(v =) 2900 \times 0.12$ (1) $(v =) 350 \text{ (m/s)}$ (1)</p>	<p>seen anywhere</p> <p>allow 348 (m/s)</p> <p>0.348, 0.35, 34800, 35000 gains 2 marks</p> <p>34.8, 35 gains 1 mark</p>	3

Question number	Answer	Additional guidance	Mark
(b)	<p>A description that makes reference to any four of the following points:</p> <ul style="list-style-type: none"> • long wavelength electromagnetic waves/radio waves cause little harm (1) • as wavelength increases, the harm/risk increases (1) • medium wavelength/ IR/microwaves only damage the surface layers/skin (1) • shorter wavelength/ultraviolet (UV) can cause damage to {cells lower down/skin cancer} (1) • very short wavelength /x-rays/gamma can cause damage {much deeper/mutation of cells/damage DNA} (1) 	<p>do not accept details of damage without reference to wavelength or region of electromagnetic spectrum</p> <p>allow correct specific details e.g. ultraviolet radiation causes sunburn</p>	4

Q4.

Question number	Answer	Notes	Marks
(a)	<p>Any FIVE from:</p> <p>MP1. measure time for a set distance;</p> <p>MP2. realistic values suggested for experiment to work;</p> <p>MP3. suitable measuring instrument named;</p> <p>MP4. further detail of setup;</p> <p>MP5. idea of repeats AND average;</p> <p>MP6. speed = distance / time;</p>	<p>A fully labelled diagram can score all the marks.</p> <p>allow measuring wavelength for a known frequency</p> <p>e.g.</p> <ul style="list-style-type: none"> • at least 1m for microphones and oscilloscope method • at least 100m for seeing and hearing a clap method • at least 50m for wall and echo method • wavelength measured at least 10cm <p>e.g. stop clock, stopwatch, ruler, tape measure, oscilloscope, trundle wheel, timer</p> <p>e.g.</p> <ul style="list-style-type: none"> • two microphones on bench connected to oscilloscope • start timing when see a clap and stop when hear it • clap by wall and time how long for clap to come back • moving a microphone until waveforms line up on oscilloscope • For echo method, idea time and distance is "there and back" <p>allow speed = frequency × wavelength for appropriate method</p>	5

(b)	(i)	Measurement of one period on oscilloscope; Use of x-scale; Evaluation of period in s; e.g. Period = 4 squares Period = 4 x 0.25 (ms) Period = 1.0 x 10 ⁻³ (s)	-1 POT error Allow 1 SF answer Condone period = 0.0005 (s) or 0.002 (s) or in standard form for 2 marks MAX.	3
	(ii)	Substitution into given equation $f = 1/ T$; Evaluation; i.e $f = 1/(1.0 \times 10^{-3})$ $f = 1000$ (Hz)	Allow ECF from b) (i)	2

Q5.

Question number	Answer	Notes	Marks	
(a)	absorbed; transmitted;		2	
(b)	x-rays are ionising / x-rays can cause cell damage; idea that dentist would have greater dose (due to taking more x-rays);	allow x-rays causing cancer / cell mutation ignore unqualified "x-rays are harmful" allow exposure for dose allow "dentist does this every day" / eq	2	
(c)	(i)	(wave) speed = frequency × wavelength;	allow rearrangements and standard symbols e.g. $v = f \times \lambda$ condone s for speed	1
	(ii)	substitution; rearrangement; evaluation; e.g. $3.0 \times 10^8 = 3.5 \times 10^{16} \times \text{wavelength}$ (wavelength =) $3.0 \times 10^8 / 3.5 \times 10^{16}$ (wavelength =) 8.6×10^{-9} (m)	seen in either order -1 for POT error allow 9×10^{-9} , 0.000000008571... condone 8.5×10^{-9} , 8×10^{-9}	3

(d)	<p>any one similarity from:</p> <p>don't need a medium to travel;</p> <p>both are transverse waves;</p> <p>both travel at the same speed (in vacuo);</p> <p>both transfer energy / information;</p> <p>any one difference from:</p> <p>radio waves have longer wavelength;</p> <p>radio waves have smaller frequency;</p> <p>x-rays are ionising / harmful but radio are not;</p>	<p>ignore they are both electromagnetic waves</p> <p>allow can travel through vacuum / space</p> <p>ignore uses of waves</p> <p>allow RA</p> <p>allow RA</p>	2
Total for question 2 = 10 marks			

Q6.

Question number	Answer	Mark
(a)(i)	A	1

Question number	Answer	Mark
(a)(ii)	B	1

Question number	Answer	Mark
(b)(i)	C	1

Question number	Answer	Additional guidance	Mark
(b)(ii)	<p>2 marks max. available for each named part of the spectrum for each use:</p> <ul style="list-style-type: none"> • 1 mark for a simple use • 1 mark for a supporting description <p>e.g.</p> <p>for gamma rays:</p> <ul style="list-style-type: none"> • used to sterilise medical tools (1) • (because) gamma kill bacteria (1) <p>for x-rays:</p> <ul style="list-style-type: none"> • used to photograph bones (1) • (because) x-rays can penetrate soft tissues but not bone (1) <p>for ultraviolet:</p> <ul style="list-style-type: none"> • used for detecting security ink (1) • (because) it fluoresces with ultraviolet lighting (1) <p>for infrared:</p> <ul style="list-style-type: none"> • used for optical fibre communications (1) • (because) they can undergo total internal reflection (1) <p>for micro waves:</p> <ul style="list-style-type: none"> • used for satellite communications (1) • (because) microwaves can penetrate Earth's atmosphere (1) <p>for radio waves:</p> <ul style="list-style-type: none"> • used for long-range communications (1) • (because) they can be reflected from the Earth's atmosphere (1) 	no mark for simply naming a part of the spectrum	6

(Total for question = 9 marks)

Q7.

Question number	Answer	Notes	Marks
(a) (i)	acceleration = change in velocity / time;	allow rearrangements and standard symbols e.g. $a = v-u / t$, $a = \Delta v/t$, $a = \Delta v/\Delta t$	1
(ii)	substitution; rearrangement; evaluation; e.g. $1.2 = (35 - 26) / t$ $t = 9 / 1.2$ (t =) 7.5 (s)		3
(b)	any four from: MP1. frequency increases; MP2. due to Doppler effect; MP3. idea that car behaves as the source of the (reflected) waves; MP4. (reflected) wavefronts closer together; MP5. (reflected) wavelength decreased; MP6. speed (of waves) stays constant;	allow "waves become bunched up" allow quotation of $v = f \times \lambda$	4

Q8.

Question number	Answer	Mark
(a)	B	1

Question number	Answer	Additional guidance	Mark
(b)(i)	Transverse	allow any recognisable spelling	1

Question number	Answer	Additional guidance	Mark
(b)(ii)	Any transverse wave e.g. electromagnetic named part of EM spectrum (surface) water waves waves on a rope seismic S waves	ignore waves on a slinky unless correctly clarified	1

Question number	Answer	Additional guidance	Mark
(c)(i)	wave speed = frequency × wavelength	equation can be given in words or symbols	1

Question number	Answer	Additional guidance	Mark
(c)(ii)	<ul style="list-style-type: none"> • Conversion of kHz to Hz OR cm to m • Substitution • Evaluation <p>e.g 2.9 kHz = 2900 Hz (1) (v =) 2900 × 0.12 (1) (v =) 350 (m/s) (1)</p>	<p>seen anywhere</p> <p>allow 348 (m/s)</p> <p>0.348, 0.35, 34800, 35000 gains 2 marks</p> <p>34.8, 35 gains 1 mark</p>	3

Question number	Answer	Additional guidance	Mark
(d)	<p>An explanation including:</p> <ul style="list-style-type: none"> • frequency decreases (1) • wavelength increases (1) • (because) wave speed is constant (1) 	<p>Ignore references to volume or loudness</p> <p>Allow 'pitch' for frequency</p>	3

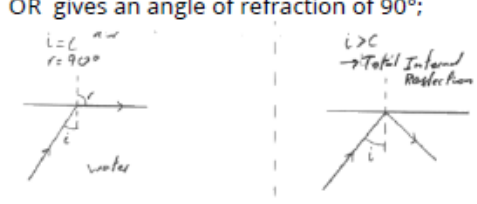
(Total for question = 10 marks)

Q9.

Question number	Answer	Notes	Marks
(a) (i)	light {refracts, bends, changes direction, changes speed, changes wavelength} = 1 mark; light {refracts/bends towards normal, slows down, wavelength decreases} = 2 marks;;		2
(ii)	normal;		1
(iii)	$\sin(c) = 1/n$;	allow in words and rearrangements	1
(iv)	substitution; rearrangement; evaluation; e.g. $\sin(c) = 1/1.6$ $(c =) \sin^{-1}(0.625)$ $(c =) 39 (^{\circ})$	allow 38.68...	3
(v)	TIR at the glass/air boundary; angle of incidence = angle of reflection;	allow ecf from (iv) that would suggest refraction e.g. if answer to (iv) is greater than 50° judge by eye	2
(b)	light ray is refracted out into the air; refracting away from the normal;	ray does not need to show deviation reject if ray emerges to the left of the normal	2

Q10.

Question number	Answer	Notes	Marks
(a)	waves change {speed / wavelength / direction} when they change medium;	allow waves bending allow any reasonable alternative to 'change medium' i.e. changing (optical) density, pass from one material to another etc.	1
(b) (i)	straight ray bent towards normal at the air-water boundary; correct angle of refraction by eye;	judge straightness of ray by eye	2
(ii)	refractive index = $\sin i / \sin r$;	allow rearrangements and standard symbols e.g. $n = \sin i / \sin r$	1
(iii)	substitution; evaluation to at least 3s.f.; e.g. ($n =$) $\sin 45 / \sin 33$ ($n =$) 1.30	reject 45/33 reject 1.36 reverse argument scores 1 mark only e.g. calculating i or r using n allow 1.298... condone 1.29	2

Question number	Answer	Notes	Marks
(c) (i)	the angle of incidence (in the slower medium); above which gives total internal reflection OR gives an angle of refraction of 90°; 	allow ideas if clear from diagram allow TIR for total internal reflection	2
(ii)	$\sin c = 1 / n$;	allow rearrangements and mixture of symbols and words	1
(iii)	substitution; rearrangement; evaluation; e.g. $\sin c = 1/1.3$ $c = \sin^{-1}(1/1.3)$ ($c =$) 50 (°)	allow 50.3, 50.28...	3
(iv)	single straight ray reflected downwards from water surface; angle correct by eye;	any ray above water surface scores zero	2