PEARSON EDEXCEL IGCSE PHYSICS · 4PH1

PHYSICS



MARK SCHEME

SECTION 3: WAVES (PACK 1)

SCORE	PERCENTAGE
/299	%

STEMUP

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Mark Scheme

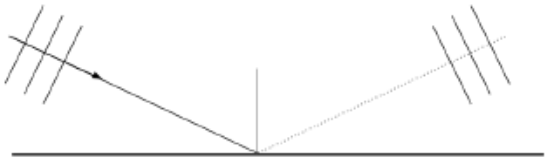
Q1.

Question number	Answer	Notes	Marks
(a)	(turning handle makes) coil **turn / rotate**; coil **cuts** through; magnetic **field** (of the permanent magnets);	reject if suggested that coil rotation is due to motor effect ignore 'interacts with'	3
(b) (i)	speed = frequency × wavelength;	allow standard symbols and rearrangements allow v, c, s for speed allow λ for wavelength	1
(ii)	substitution; rearrangement; evaluation; e.g. $3.0 \times 10^8 = 93 (\times 10^6) \times$ wavelength wavelength = 3.0×10^8 / $93 (\times 10^6)$ (wavelength =) 3.2 (m)	ignore units until evaluation 1 mark may be awarded in the absence of any others for correctly converting MHz to Hz POT error scores 2 marks max. allow 3.2258...(m)	3
(c) (i)	any four from: MP1. loudspeaker (coil) has a current / magnetic field; MP2. interaction between magnetic fields; MP3. causes a force to be exerted on speaker (cone); MP4. a.c. changes direction; MP5. force on speaker (cone) changes direction; MP6. causes speaker (cone) to vibrate;	allow 'interferes' for interacts	4
(ii)	any one from: increase strength of magnet; use a larger current; use more turns of wire on loudspeaker coil;	ignore references to adding iron core ignore 'increase size of magnet' allow larger voltage (across coil) allow 'more coils of wire'	1
		Total for Question = 12 marks	

Q2.

Question number	Answer	Notes	Marks
(a)	any FOUR from: MP1. idea of magnetic field around coil (when current flows); MP2. idea of interaction between fields of magnet and coil; MP3. idea of force on coil from magnet; MP4. idea of alternating force on cone; MP5. cone vibrates; MP6. idea that cone forces air to vibrate; MP7. longitudinal wave formed;	ignore references to induction allow 'tube' for 'cone' allow idea of series of compressions and rarefactions	4
(b) (i)	substitution; evaluation; correct answer = 0.11 (W) e.g. power = current × voltage = 0.15 × 0.75 power = 0.1125 W	-1 for POT error	2
(ii)	suitable linear scale chosen (>50% of grid used); axes labelled with quantities and units; all plotting correct to nearest half square;	ignore orientation	3
(iii)	attempt at fitting first two points and fitting rest of points separately; single curve with a peak within one large square of third point;	ecf candidate's plotting max 1 mark for straight line consistent with candidate's plotting	2
(c)	any FOUR from: MP1. for diagram 4, cell voltage no longer shared; MP2. means current through each loudspeaker is doubled; MP3. so current from supply is four times higher; MP4. correct use of 'R = V/I'; MP5. (so) total resistance is a quarter of that from the series case;	accept voltages in parallel are the same accept voltage is shared in diagram 3 accept idea of current from each branch adds to give total current in cell accept higher order answers in terms of series and parallel equations accept calculation of both circuit's total resistance	4
			(Total for Question = 15 marks)

Q3.

Question number		Answer	Notes	Marks
(a)	(i)	line drawn at 90 degrees to side of boat at point where direction of travel touches boat;	ignore normal inside boat	1
	(ii)	66 (degrees);	accept in range 64-68 degrees	1
	(iii)	three wavefronts parallel and constant wavelength;	by eye; condone different wavelength to incident wavefronts	3
		to the right of the normal and above boat surface; correct angle of reflection; 	by eye; allow 'reflected ray' if no other mark awarded	
(b)	(i)	transverse (waves/particles) vibrate at right angles to the direction of travel of the wave; longitudinal (waves/particles) vibrate along line of direction of travel of the wave;	allow 'vibrations/oscillates at...' allow 'perpendicular to' for 'at right angles' allow 'energy transfer' for 'travel' allow '(anti-)parallel to' for 'along'	2
	(ii)	wavelength or distance between wavefronts smaller; speed of waves is constant; reference to wave equation $v = f\lambda$;	if no other marks awarded, 1 mark for reference to Doppler effect	3
			(Total for Question = 10 marks)	

Q4.

Question number	Answer	Notes	Marks
(a) (i)	36 (degrees);		1
(ii)	refractive index = sin(i) / sin(r);	allow standard symbols and rearrangements e.g. n = sin(i) / sin(r)	1
(iii)	substitution; evaluation; answer quoted to 2 s.f.; e.g. refractive index = sin(61) / sin(36) (refractive index =) 1.48799... (refractive index =) 1.5	allow ecf from (i) mark independently	3
(b)	red refracts less than violet; correct link made between colour and refractive index; correct link made between wavelength and refractive index;	allow RA allow red bends less than violet e.g. red has a lower refractive index than violet e.g. refractive index decreases with increasing wavelength	3

Q5.

Question number	Answer	Notes	Marks
(a)	D (the Sun); A is incorrect because a comet is the smallest object B is incorrect because the Earth is smaller than the Sun C is incorrect because the Earth and the Sun are larger than the Moon		1
(b)	A (alpha); B is incorrect because beta is less ionising than alpha C is incorrect because gamma is less ionising than alpha D is incorrect because gamma has a higher frequency than UV so is more ionising		1
(c)	B (ohm); A is incorrect because ampere is the unit for electric current C is incorrect because volt is the unit for voltage D is incorrect because watt is the unit for power		1
(d)	D (x-ray); A is incorrect because infrared has a longer wavelength than ultraviolet and x-ray B is incorrect because microwave has the longest wavelength C is incorrect because ultraviolet has a longer wavelength than x-ray		1
(e)	C (273 K); A is incorrect because this is subtracting 273, rather than adding 273 B is incorrect because this is adding 3, rather than adding 273 D is incorrect because this is adding 373, rather than adding 273		1
		Total for question = 5 marks	

Q6.

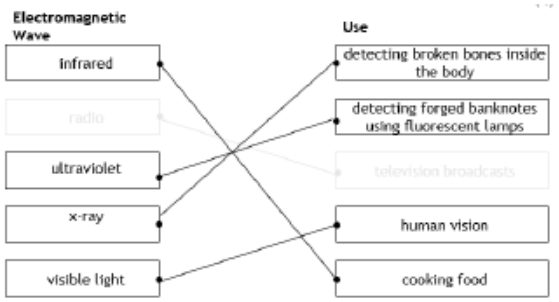
Question number	Answer	Notes	Marks
(a) (i)	sin(c) = 1/n;	allow rearrangements and/or words for symbols	1
(ii)	substitution; rearrangement; correct evaluation to 5 s.f.; e.g. sin(88.500) = 1/n n = 1/sin(88.500) n = 1.0003	answer of 1.00034... scores 2 marks	3
(b) (i)	straight line drawn passing into atmosphere above normal line; line bends towards normal;	DOP accept any bend towards normal however small	2
(ii)	angle of incidence is zero; angle of refraction must be zero also;	allow idea that ray 'hits' atmosphere at 90°, ray is travelling along the normal allow angle of refraction is equal to angle of incidence	2
(iii)	any two from: • reference to speed = frequency × wavelength; • frequency is constant; • speed decreases (so wavelength must decrease);		2
(iv)	any one from: • idea that rays of light from different parts of the Sun refract by different amounts; • amount of refraction very large (when Sun is close to the horizon);		1
		Total for Question = 11 marks	

Q7.

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>(a)</td><td>
<table>
<tr><th>thermometer</th><th>part of spectrum</th></tr>
<tr><td>P</td><td>infrared;</td></tr>
<tr><td>Q</td><td>red</td></tr>
<tr><td>R</td><td>green / yellow;</td></tr>
<tr><td>S</td><td>violet</td></tr>
<tr><td>T</td><td>ultraviolet;</td></tr>
</table>
</td><td>allow all valid colours/ visible</td><td>3</td></tr>
<tr><td>(b)</td><td>any reference to absorption;

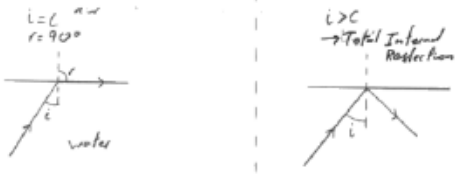
black is the better/best/good absorber;</td><td>allow reference to reflection
allow reference to ‘poor reflector’</td><td>2</td></tr>
<tr><td>(c)</td><td>infrared/IR;</td><td></td><td>1</td></tr>
<tr><td colspan="4">(Total for Question = 6 marks)</td></tr>
</table>

Q8.

Question number	Answer	Notes	Marks
(a)	;;;;  		4
(b)	skin burns;	apply 'list' principle allow 'damage to skin cells'	1
(c)	reduce time of exposure/ increase distance from source/ introduce more material between source and person; e.g. suncream, clothing, sunglasses, staying indoors, stay behind glass windows, only stay outside for 20 minutes without sun protection	apply 'list' principle	1
			(Total for Question = 6 marks)

Q9.

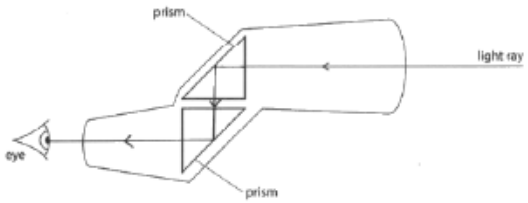
Question number	Answer	Notes	Marks
(a)	waves change {speed / wavelength / direction} when they change medium;	allow waves bending allow any reasonable alternative to 'change medium' i.e. changing (optical) density, pass from one material to another etc.	1
(b) (i)	straight ray bent towards normal at the 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 =) sin45 / sin33 (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

Q10.

Question number	Answer	Notes	Marks
(a)	D (ultraviolet); A is incorrect because frequencies lower than visible light are non-ionising B is incorrect because frequencies lower than visible light are non-ionising C is incorrect because frequencies lower than visible light are non-ionising		1
(b)	one use for x-rays; e.g. taking photos or detecting of (broken) bones, internal structures (of objects), one use for gamma rays; e.g. radiotherapy, sterilising medical equipment, reference to tracing, airport scanning of luggage, irradiating food (for preservation)	 allow treating cancer / sterilising medical equipment allow treating cancer	2
(c) (i)	speed = frequency × wavelength;	allow standard symbols and rearrangements e.g. $\lambda = v / f$ condone s for speed	1
(ii)	substitution; rearrangement; evaluation; e.g. $3.0 \times 10^{8} = 2.8 \times 10^{19} \times$ wavelength wavelength = speed / frequency (wavelength =) 1.1×10^{-11} (m)	 -1 for POT error allow $1.07... \times 10^{-11}$ (m)	3
(d)	B; A is incorrect because it shows an exponential relationship C is incorrect because it shows a proportional relationship D is incorrect because it shows no relationship		1

Q11.

Question number	Answer	Notes	Marks
(a)	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 where light is refracted along the media boundary	2
(b)	TIR in both prisms; no refraction as ray enters and leaves prisms; emergent ray parallel to incident ray; 		3

Q12.

Question number	Answer	Notes	Marks
(a)	17 (degrees);	Allow in range 15-19 degrees	1
(b)	refractive index = sin(i) / sin (r);	accept n or η for refractive index accept any valid rearrangement	1
(c)	substitution; evaluation of either sine correctly; evaluation; e.g. refractive index = sin(29)/sin(17) refractive index = 0.484.../0.292... refractive index = 1.7	allow ecf from (a) 0.48480962/0.292371705 1.6581961	3
		(Total for Question = 5 marks)	

Q13.

Question number	Answer	Notes	Marks
(a) (i)	correctly reflected ray of light drawn at A;	judge angle of reflection = angle of incidence by eye allow dotted lines, lines without arrowheads ignore lines inside the block	1
(ii)	i = 60 (°); r = 31 (°);	allow 59-61 inclusive allow 30-32 inclusive	2
(iii)	n = sin(i) / sin(r);	allow in words and rearrangements	1
(iv)	substitution; evaluation; e.g. (n =) sin(60) / sin(31) (n =) 1.68	allow ECF from (ii) allow 1.61-1.75	2
(v)	any three from: MP1. take repeat readings **at a specific angle**; MP2. vary angle of incidence; MP3. find mean values for one angle i / mean refractive index; MP4. plot graph of sin(i) against sin(r); MP5. find refractive index from gradient of graph;	ignore bald "repeat and average" ignore "repeat investigation"	3
(b)	ray drawn with smaller angle of refraction than red light when it enters block; ray bends away from the normal when it leaves the glass block; ray drawn parallel to red light as it leaves block;		3

Q14.

Question number	Answer	Notes	Marks
(a)	protractor;		1
(b) (i)	any indication that the angle is between the normal and the incident ray;		1
(ii)	79 (degrees);	allow 78-80 (degrees) ecf from indicated angle of incidence in (i) e.g. 10-12 (degrees) if angle marked between ray and boundary	1
(iii)	any straight ray to the right of the normal that comes from the point of incidence; correct angle of reflection;	judge by eye judge by eye	2

Q15.

Question number	Answer	Notes	Marks
(a)	any two from: MP1. ruler; MP2. protractor; MP3. named suitable light source; MP4. optical pin(s);	 e.g. ray box, light box, laser ignore torch	2
(b) (i)	ray drawn bending in the correct direction; ray drawn parallel to ray before it enters the block;	 judge by eye	2
(ii)	normal drawn perpendicular to block's surface where light ray enters;	judge by eye normal must be drawn in both air and block	1
(iii)	angle of incidence = 44 (degrees); angle of refraction = 26 (degrees);	allow 43-45 allow 25-27	2
(iv)	refractive index = $\frac{\sin(\text{angle of incidence})}{\sin(\text{angle of refraction})}$;	allow standard symbols and rearrangements e.g. n = sin(i) ÷ sin (r)	1
(v)	substitution; evaluation; e.g. (n =) sin44 / sin26 (n =) 1.6	allow ecf from (iii) allow range 1.5-1.7	2
(c)	idea that multiple angles (of incidence) measured; graph of sin(i) against sin(r) plotted; **gradient** of graph = refractive index;	 can be gained from diagram ignore orientation of axes can be gained from diagram reject if inconsistent with graph. However, accept if sin(r) on y-axis then gradient = 1/n	3
		Total for Question = 13 marks	

Q16.

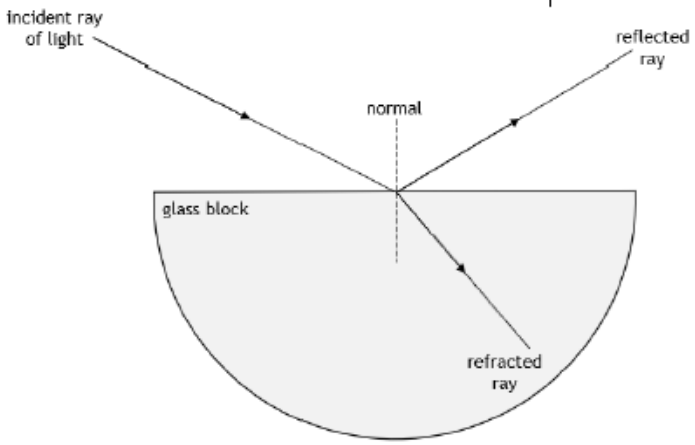
Question number	Answer	Notes	Marks
(a) (i)	line drawn in top-right quadrant; correct angle by eye;	accept if drawn on diagram 1 instead of diagram 2 DOP	2
(ii)	32 (degrees);	allow in range 31-33 (degrees)	1
(iii)	refractive index = sin(angle of incidence) / sin(angle of refraction);	allow standard symbols and rearrangements e.g. 'i' for angle of incidence 'r' for angle of refraction 'n' for refractive index	1
(iv)	substitution; evaluation to at least 3s.f.; e.g. n = sin(64) / sin (32) n = 1.70	allow ecf from (ii) allow 1.696...	2
(v)	sin(c) = 1 / n;	allow standard symbols and rearrangements	1
(vi)	substitution OR rearrangement; evaluation; e.g. sin(c) = 1/1.7 OR c = $\sin^{-1}(1/n)$ (c =) 36 (degrees)	allow ecf from (iv) allow 36.03...(degrees)	2
(b)	light undergoes total internal reflection; angle of incidence is above the critical angle; light (would be) going from more (optically) dense to less (optically) dense;	allow TIR for 'total internal reflection' allow idea that light would speed up if it travelled through the boundary / light travels faster in air than in material	3
		Total for Question = 12 marks	

Q17.

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 (°)	 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

Q18.

Question number	Answer	Notes	Marks
(a) (i)	normal drawn perpendicular to boundary at point where ray of light is incident;	line can be drawn on either side of boundary or passing through boundary judge perpendicular by eye	1
(ii)	straight refracted ray drawn passing into block and continuing path to the right; refraction drawn correctly;	refracted ray must be labelled DOP	2
(iii)	straight reflected ray drawn reflecting from boundary and continuing path to the right; angle of reflection drawn equal to angle of incidence;	reflected ray must be labelled DOP	2



(b)	any six from: MP1. suitable light source; MP2. draw around block on paper; MP3. mark point where light will enter block; MP4. shine light into block and measure angle of incidence; MP5. use of protractor (to measure angle); MP6. mark point where ray exits block; MP7. use of ruler to draw path of (refracted) ray; MP8. measure angle of refraction; MP9. repeat for different angles of incidence; MP10. use of graph to show data;	allow any marking point if clear on diagram e.g. ray box, laser, light box allow idea of drawing normal at point where light enters block	6

Q19.

Question number	Answer	Notes	Marks
(a)	any five from MP1-MP7: apparatus: MP1. method of creating thin beam of light; MP2. protractor; method: MP3. draw round the block; MP4. shine light into the block at an angle to the normal; MP5. mark incident and refracted rays; MP6. measure angles from the normal; MP7. repeat for different angles of incidence; PLUS MP8. graph of sin(i) and sin(r) with n found from gradient	allow marking points from diagram e.g. laser, ray box etc. ignore torch however expressed allow simple use of n=sin(i)/sin(r)	6
(b)	optical fibres; named prismatic use e.g. cats eye reflector, binoculars, periscope etc;		2

Q20.

Question number	Answer	Notes	Marks
(a) (i)	47 (°);		1
(ii)	sin(c) = 1 / n;		1
(iii)	substitution OR rearrangement; evaluation; e.g. sin(47) = 1/n OR n = 1/sin(c) (n =) 1.4	allow ecf from (i) answer is 1.37 to 3sf if (i) is given as 43° then expected answer is 1.5 to 2sf /1.47 to 3 sf	2
(b)	ray is refracting / angle of incidence is less than critical angle; critical angle for water is greater than for acetone; refractive index of water is less than for acetone;	award full marks for a correct calculation of the refractive index of water with correct conclusion e.g. $n_{water} = 1.33 < n_{acetone}$ Allow correct conclusion with $n_{water} = 0.75...$ for 1 mark MAX reject response with otherwise incorrect calculation of n_{water}	3

Q21.

Question number	Answer	Notes	Marks
(a) (i)	any one from: satellite orbits a planet/Earth, planet orbits a star/Sun; orbital radius/time period of planet is greater than satellite;	 both aspects of the comparison required allow RA allow planet's orbit is larger	1
(ii)	any one from: both orbit a planet/Earth; both have same shape of orbit;	 allow circular or elliptical	1
(b) (i)	substitution into $v = 2\pi \times r / T$; conversion of 24 hours into seconds; rearrangement and evaluation of orbital radius; evaluation of height; e.g. $3.1 = 2 \times \pi \times r / [24 \times (60 \times 60)]$ $T = (24 \times 60 \times 60 =) 86\,400$ (s) $r = 42628$ (km) (height = 42628 - 6400 =) 36 000 (km)	ignore units allow 86 400 seen anywhere allow 36228.05996 (km)	4
(ii)	any three from: MP1. speed of waves constant; MP2. if source moving away, wavefronts spread out / wavelength increases; MP3. speed = frequency × wavelength; MP4. (higher wavelength and constant speed of waves) gives lower frequency;	 allow RA for source approaching allow RA for source approaching	**3**
(iii)	idea that there is no (relative) motion between point on Earth's surface and satellite; (therefore) no wavelength/frequency change;	allow distance to satellite from Earth does not change DOP	2
		Total for Question = 11 marks	

Q22.

Question number	Answer	Notes	Marks
(a) (i)	reflection;		1
(ii)	substitution into speed = distance / time; rearrangement; evaluation of correct total distance; halved to find distance to fish; e.g. 1500 = distance / 0.043 distance = speed × time (distance =) 64.5 (distance = 64.5 ÷ 2) = 32 (m)	ignore units condone incorrect conversion of time from 43 ms i.e. 43, 43/60, 43 × 1000, 43 × 60 accept wherever applied i.e. to the time or to the distance travelled. 64.5, 65 = 3 marks (no halving) 32250 etc = 3 marks (POT) 64500 etc = 2 marks (POT and no halving)	4
(b) (i)	3.0 ± 0.5 (cm);	accept '3'	1
(ii)	any three from: MP1. all frequencies show reduction in amplitude or intensity with distance; MP2. this reduction is non-linear; MP3. penetration decreases with increasing frequency; MP4. use of data from graph to justify MP3;	ignore 'inverse proportion' condone '(negative) exponential' however expressed e.g. 2MHz penetrates more than 4 MHz which penetrates more than 10MHz e.g. relative values at a given distance or distances at which the frequencies are at a given value	3

Q23.

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)	• Conversion of kHz to Hz OR cm to m • Substitution • Evaluation e.g. 2.9 kHz = 2900 Hz (1) (v =) 2900 x 0.12 (1) (v =) 350 (m/s) (1)	seen anywhere allow 348 (m/s) 0.348, 0.35, 34800, 35000 gains 2 marks 34.8, 35 gains 1 mark	3

Question number	Answer	Additional guidance	Mark
(b)	A description that makes reference to any four of the following points: • 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)	do not accept details of damage without reference to wavelength or region of electromagnetic spectrum allow correct specific details e.g. ultraviolet radiation causes sunburn	4

Q24.

Question number	Answer	Notes	Marks
(a) (i)	(average) speed = distance / time;	allow standard symbols and rearrangements e.g. v = s/t allow s for speed and d for distance	1
(ii)	substitution; evaluation; e.g. (speed =) 1860 / 5.6 (speed =) 330(m/s)	 allow 332.14...(m/s)	2
(iii)	light travels faster than sound; he sees explosion before hearing it;	allow idea that they travel at different speeds but not that sound travels faster Allow RA	2
(b)	vibrations (of particles) are parallel; to direction the wave travels;	allow oscillations for vibrations DOP allow direction of energy transfer	2
(c) (i)	kinetic energy = ½ × mass × speed^2;	allow standard symbols and rearrangements e.g. KE = ½ × m × v^2	1
(ii)	substitution; evaluation; e.g. (KE =) 0.5 × 1.25 × 10^7 × 19200^2 (KE =) 2.30 × 10^{15} (J)	 -1 for POT error allow 2.304 × 10^{15} (J)	2

Q25.

Question number	Answer	Notes	Marks
	Any FIVE from: MP1 reference to Doppler effect; MP2 wavefronts are emitted at constant frequency by buzzer; MP3 wavefronts arrive at student (A) further apart than when they were emitted; MP4 distance between wavefronts is the wavelength; MP5 speed = frequency × wavelength; MP6 speed of waves is constant; MP7 as speed is constant and wavelength has increased, frequency must decrease; MP8 decrease in frequency is experienced as a decrease in pitch;	Allow 'wavelength increases' if MP3 or MP4 not awarded	5
		(Total for Question = 5 marks)	

Q26.

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)	• Conversion of kHz to Hz OR cm to m • Substitution • Evaluation e.g 2.9 kHz = 2900 Hz (1) (v =) 2900 x 0.12 (1) (v =) 350 (m/s) (1)	seen anywhere allow 348 (m/s) 0.348, 0.35, 34800, 35000 gains 2 marks 34.8, 35 gains 1 mark	3

Question number	Answer	Additional guidance	Mark
(d)	An explanation including: • frequency decreases (1) • wavelength increases (1) • (because) wave speed is constant (1)	Ignore references to volume or loudness Allow 'pitch' for frequency	3

(Total for question = 10 marks)

Q27.

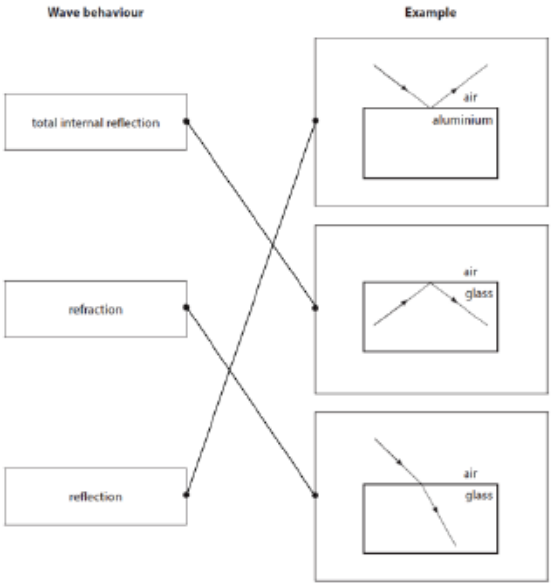
Question number	Answer	Notes	Marks
(a)	40 000 {waves / vibrations / oscillations}; in 1 second / unit time;	allow 40 000 wavelengths / wavefronts allow per second	2
(b) (i)	(wave) speed = frequency × wavelength;	allow standard symbols and rearrangements e.g. $\lambda = v / f$ condone s for speed ignore incorrect symbols e.g wl for wavelength, ws for wave speed	1
(ii)	substitution; rearrangement; evaluation; e.g. $345 = 40\,(000) \times \lambda$ $\lambda = 345/40\,(000)$ $(\lambda =)\ 8.6 \times 10^{-3}$ (m)	POT error = -1 correct answer with no working gains full marks 8.6, 8.62, 8.63, 8.625 = 2 marks allow 9×10^{-3}, 8.62×10^{-3}, 8.63×10^{-3}, 8.625×10^{-3} (m)	3
(iii)	use of speed = distance/time seen or implied; factor of 2 seen; substitution; evaluation; e.g. speed = distance/time distance should be doubled $345 = 4.70 \div$ time (time =) 0.0136 (s)	allow any rearrangement or in correct symbols allow d, s, x for distance allow v for speed condone s for speed 0.007, 0.0068... scores 3 marks (no factor of 2 used) allow 0.01, 0.014, 0.01362... (s)	4

(c)	idea that the person can see/know what (distance) they are measuring/eq;	e.g. marks the position that (distance) is being measured to	1
(d)	any three from: MP1. sound is longitudinal light is transverse; MP2. sound vibrations are in the direction of travel, light vibrations are perpendicular to the direction of travel; MP3. light is electromagnetic, sound is not; MP4. light can travel through a vacuum/space, sound cannot; MP5. light travels (much) faster (in air) than sound; MP6. light slows down in denser medium but sound speeds up;	allow points shown on a labelled diagram allow higher level ideas i.e. light can be polarised but sound can't allow reverse argument (RA) for all marking points can be given from diagram showing longitudinal and transverse waves allow oscillations, displacements for vibrations allow direction of energy transfer for direction of travel allow sound is mechanical, light is not allow sound needs a medium but light does not allow quoted speeds for comparison	3
		Total for Question = 14 marks	

Q28.

Question number	Answer	Notes	Marks
(a) (i)	acceleration = change in velocity / time;	allow rearrangements and standard symbols e.g. a = v-u / t, a = Δv/t, a = Δv/Δt	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

Q29.

Question number	Answer	Notes	Marks
(a)	one mark for each correct line drawn;;;  	allow line for reflection drawn to first or second example diagram allow two lines drawn from reflection to first and second diagrams only reject mark if two lines drawn from either TIR or refraction	3
(b)	any two from: (all waves) reflect; (all waves) refract; idea that (all waves) transfer energy (without transferring matter); (all waves) have amplitude/wavelength/frequency;	allow higher level common properties e.g. diffraction, interference etc. allow 'information' for energy	2
		Total for Question = 5 marks	

Q30.

Question number	Answer	Notes	Marks
(a) (i)	travel at the same speed (in a vacuum) / can travel in a vacuum;	allow both transverse waves, both transfer energy, both microwaves	1
(ii)	wavelength;	allow idea of different range / penetration ignore amplitude	1
(b) (i)	speed = frequency × wavelength;	allow standard symbols and rearrangements e.g. $\lambda = v / f$ allow c for speed ignore s for speed	1
(ii)	substitution OR rearrangement; evaluation; e.g. $3.0 \times 10^8 = 5.2 \times 10^9 \times \lambda$ OR $\lambda = v / f$ (wavelength =) 0.058 (m)	-1 for POT error allow 0.06, 0.0576...(m)	2
(c) (i)	D; A is incorrect because electromagnetic waves are not longitudinal B is incorrect because electromagnetic waves are not mechanical waves C is incorrect because sound waves are not electromagnetic waves		1
(ii)	vibrations / oscillations; correct relationship between direction of travel/energy transfer and direction of vibration for both transverse and longitudinal waves;	both marks can be scored from a suitable diagram allow movement of particles / eq for vibrations for this mark	2

Q31.

Question number	Answer	Notes	Marks
(a)	sensible linear scales; axes labelled with units; all points plotted correctly within ½ a small square;	e.g. occupy >50% of the grid and not multiples of 3 etc. check 3rd and 6th point	3
(b)	smooth curve that passes through all data points;	allow if within ½ a small square of each data point allow ecf from plotting in (a)	1
(c)	idea that as wind speed increases the wavelength increases; idea of non-linear relationship;	ignore positive correlation "wavelength proportional to wind speed **squared**" scores both marks	2
(d)	350 m wavelength is achieved when wind speed is 26-27 m/s; ship is shorter than wavelength so is not likely to be damaged;	allow RA e.g. 29 m/s wind speed gives wavelength of 400-450 m DOP	2

Wind speed in m/s	Wavelength of waves on the surface of the sea in m
0	0
5	12
10	49
15	110
20	196
25	306
30	441
35	600

Q32.

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

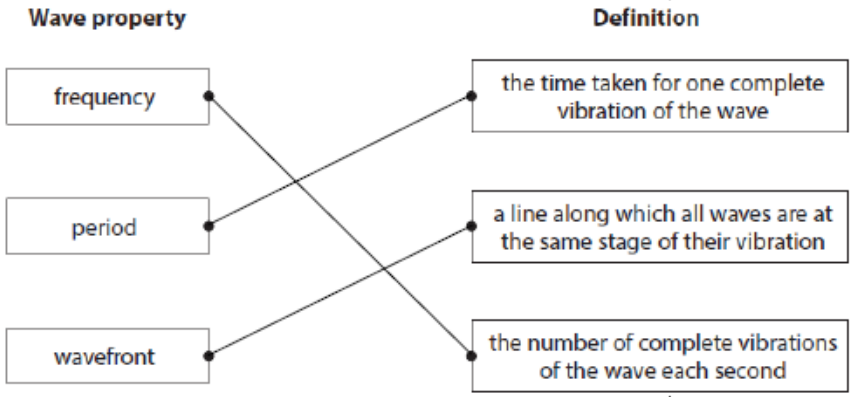
Question number	Answer	Mark
(a)(ii)	B	1

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

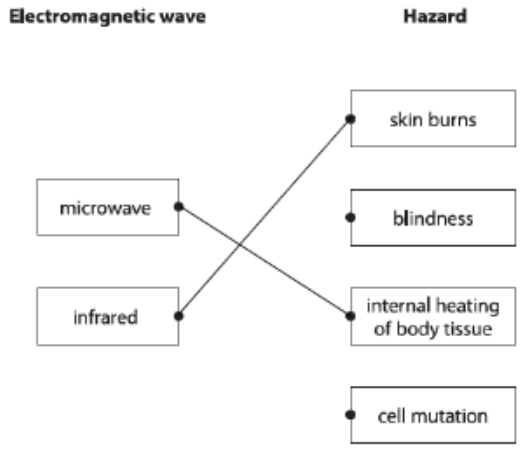
Question number	Answer	Additional guidance	Mark
(b)(ii)	2 marks max. available for each named part of the spectrum for each use: • 1 mark for a simple use • 1 mark for a supporting description e.g. for gamma rays: • used to sterilise medical tools (1) • (because) gamma kill bacteria (1) for x-rays: • used to photograph bones (1) • (because) x-rays can penetrate soft tissues but not bone (1) for ultraviolet: • used for detecting security ink (1) • (because) it fluoresces with ultraviolet lighting (1) for infrared: • used for optical fibre communications (1) • (because) they can undergo total internal reflection (1) for micro waves: • used for satellite communications (1) • (because) microwaves can penetrate Earth's atmosphere (1) for radio waves: • 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)

Q33.

Question number	Answer	Notes	Marks
(a) (i)	D; A is incorrect because it shows the amplitude B is incorrect because it shows half the wavelength C is incorrect because it shows double the amplitude		1
(ii)	A; B is incorrect because it shows half the wavelength C is incorrect because it shows double the amplitude D is incorrect because it shows the wavelength		1
(b)	correct lines showing all three properties linked to their definitions;; any one line correct; e.g.  	reject line if property is linked to more than one definition	2
(c)	D; A is incorrect because both waves transfer energy and can be reflected and refracted B is incorrect because both waves can be reflected and refracted C is incorrect because both waves transfer energy		1
		Total for question = 5 marks	

Q34.

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;;  	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