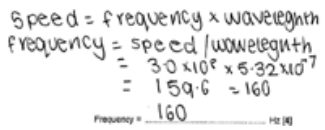
Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1	a		Refraction ray drawn with angle of refraction smaller than angle of incidence ✓	1 AO 1.2	Judge by eye **IGNORE** direction of arrow and length of ray
	b		Glass is more (optically) dense than air ✓ The speed of light is lower in glass ✓	2 AO 2 × 1.1	**ALLOW** glass has a different (optical) density (to air) **DO NOT ALLOW** glass is less (optically) dense **ALLOW** glass has a different refractive index (to air) **ALLOW** (the light) slows down **DO NOT ALLOW** the speed of light is higher in glass **IGNORE** ideas about wavelength and frequency **If no other mark scored:** **ALLOW** light changes speed (in glass) **<u>Examiner's Comments</u>** Candidates demonstrated good knowledge of refraction in this question with the majority of candidates achieving at least 1 mark, mainly for identifying that glass is denser than air.
			Total	**3**	
2	a	i	Visible light has a larger frequency (than infrared) / **ORA** ✓ Visible light has shorter wavelength (than infrared) / **ORA** ✓	2 (2 x AO 1.1)	**IGNORE** longer/shorter frequency
		ii	**Any two from:** Count number of waves (passing a point) ✓ Measure time (for these waves with a stopwatch) ✓ Divide number of waves (passing a point) by the time (for these waves) ✓	2 (2 x AO 2.2)	**ALLOW** count how many times an object e.g. cork bobs up and down **IGNORE** time it takes waves to travel a certain distance **ALLOW** count number of waves in a certain time for 2 marks **If no other marks scored:** (idea that) frequency is the number of

			Alternative method (idea of) measure time period / time for 1 wave ✓ Use frequency = 1 ÷ time period ✓		waves per second for 1 mark **Examiner's Comments** The majority of candidates gained full credit for the idea of counting the number of waves passing a point in a certain time. The most common errors stemmed from not reading the question carefully enough and changing the scenario, e.g. using a ripple tank and using the equation $f = v \div \lambda$.
	b		**First check the answer on the answer line** **If answer = 5.6 × 10^{14} (Hz) award 4 marks** Select and rearrange: (frequency =) wave speed ÷ wavelength / f = v ÷ λ ✓ (f =) 3 x 10^{8} ÷ 5.32 x 10^{-7} ✓ (f =) 5.639... × 10^{14} ✓ (f =) 5.6 × 10^{14} (Hz) (2 s.f.) ✓	4 (AO 1.2) (AO 2.1) (AO 2.1) (AO 1.2)	**ALLOW** correct substitution into unrearranged equation for 1 mark **ALLOW** 5.639...x 10^{n} for 2 marks **ALLOW** 5.6 x 10^{n} for 3 marks **ALLOW** this mark for clear evidence of an incorrect answer (correctly rounded) to two significant figures (not a bald answer to 2 s.f.) **Examiner's Comments** This question required candidates to identify and rearrange the relevant equation from the Equation Sheet to find frequency, and then to give the final answer to 2 significant figures. Candidates performed well on this question, with the majority gaining full credit. Common errors included: • incorrectly rearranging the equation • making an error when using the calculator to give a final answer with an incorrect power of ten • not giving the final answer to 2 significant figures **Assessment for learning** Candidates should, as always, note how essential it is to write down every

					step of their workings so that compensatory marks can be given if the final answer is incorrect. Exemplar 1  The final answer is incorrect and would have scored zero marks if the candidate had not shown their working. The candidate has successfully rearranged the equation, but not substituted the values into it correctly. There is also clear evidence of an incorrect answer given to two significant figures so the candidate scores 2 out of the possible 4 marks.
			Total	**8**	
3			B	1 (AO 1.2)	
			Total	**1**	
4			A	1 (AO 2.1)	**Examiner's Comments** Nearly all candidates were able to substitute the values into the equation provided correctly in order to calculate a distance of 0.030 m. However, the majority of candidates did not take into account that the distance they had calculated was from the emitter to the soft tissue-bone boundary and back to the receiver, and therefore they made the common error of not halving their answer.
			Total	**1**	
5			D	1 (AO 1.1)	
			Total	**1**	
6			**D**	1 (AO 1.1)	**Examiner's Comments** Just over half of candidates answered this question correctly, with many candidates incorrectly thinking that the gel amplifies the ultrasound waves.

			Total	**1**	
7			**B**	1 (AO 1.1)	**ALLOW** 10 (ms)
			Total	**1**	
8			**A**	1 (AO 1.1)	
			Total	**1**	
9	a	i	The sound reflects/echoes (from the cliff) ✓ The amplitude of the sound decreases with distance / some of the energy/wave/sound is absorbed (by the cliff/air) ✓	2 (2 × AO1.1)	**IGNORE** bounces **ALLOW** energy lost as travelling through air / energy dissipated into surroundings/cliff **ALLOW** sound/waves/energy spreads out **ALLOW** some sound/waves/energy reflect/travel in different directions **IGNORE** just energy lost **Examiner's Comments** The majority of candidates gained both marks. Of those that did not, it was usually from the lack of scientific terminology, e.g. bounce back instead of reflect, or insufficient detail to explain why the second clap is quieter, e.g. energy is lost.
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 231 (m) award 4 marks** (distance =) speed × time ✓ (distance travelled by wave =) 330 ×1.40 ✓ (distance travelled by wave =) 462 (m) ✓ (distance to cliff =) ½ × 462 = 231 (m) ✓	4 (AO1.2) (3 × AO2.1)	**ALLOW** symbol equation / equation in any form **ALLOW** 0.7 seen for 1 mark **ALLOW** 330 × 0.7 for 3 marks **ALLOW** 3 marks for answer of 462(m) **Examiner's Comments** Nearly all candidates gained full marks or 3 marks. Several candidates did not gain the last mark because they did not divide either the time or their answer for distance by two.
		iii	**Any two from:** Due to reaction time ✓ Sound may not be heard (clearly) ✓ The student might start the stopwatch too early / stop the stopwatch too late / be distracted ✓	2 (2 × AO3.2a)	**IGNORE** human error **ALLOW** cliff surface is not flat so waves take different times to return **ALLOW** starts/stops stopwatch at the wrong time / can't clap and press button at the same time

			Wind/temperature/humidity/rain affects the speed ✓		**IGNORE** weather conditions **Examiner's Comments** Most marks were gained for ideas about reaction time, pressing the stopwatch too early/late and the difficulty in clapping and pressing the stopwatch at the same time. Of the candidates who did not score both marks, most answers usually referred to human error.
		iv	**Any one from:** Repeat the measurements and take a mean ✓ (Idea of) recording sound (and playback) to find accurate time ✓ Use another person (next to first student) to measure the time between clap and echo ✓	1 (AO3.3b)	**ALLOW** (idea of) clap-echo method / measuring time for multiple claps **ALLOW** (idea of) a method using microphone(s) linked to computer/oscilloscope/electronic timers **Examiner's Comments** The improvements suggested often followed on from the candidate's answer to part (a) (iii) and most candidates were given the mark. Incorrect responses often referred to inappropriate technology such as light gates or vaguely described sound-activated timers. **Assessment for learning** It would be beneficial for students to think about which improvements could be made to their method each time they carry out an experiment.
	b	i	**Any two from:** (Sound travels as) a longitudinal wave ✓ (Sound travels as) compressions and rarefactions ✓ Air particles vibrate ✓ Vibrations are <u>parallel</u> to the direction of energy transfer/wave travel ✓	2 (2 × AO1.1)	**Examiner's Comments** Many candidates described how sound travels through the ear. This question was a good discriminator and only the more able candidates gained both marks, usually by referring to air particles vibrating and compressions and rarefactions. Marks were not awarded for vague references e.g. 'sound waves vibrating'.

		ii	**Any two from:** Outer ear/pinna/auditory canal (transfers sound to ear drum) ✓ Ear drum (vibrates) ✓ (passed to/vibrates) ossicles/small bones/anvil/hammer/stirrup ✓ (Liquid in) cochlea (transmits movement to small hairs) ✓ Hairs/cilia (vibrate) ✓	2 (2 × AO1.1)	If vibrations not mentioned, maximum of 1 mark **ALLOW** vibrates/oscillations/oscillates/moves in and out for idea of vibrations **ALLOW** ossicles/small bones/anvil/hammer/stirrup amplify vibration **Examiner's Comments** The majority of candidates gained at least 1 mark for this question. Nearly all candidates could name at least two parts of the ear, but some did not score the second mark as they did not mention that one or more parts of the ear had to vibrate for the sound to travel through.
	c		Wavelength of **A** is longer (than **B**) / double (**B**) / **ORA** ✓ And any **one** from: Wavelength is inversely proportional to frequency ✓ Wavelength = wave speed ÷ frequency and speed (of sound) is constant ✓ As frequency decreases, wavelength increases ✓ As frequency halves, wavelength doubles ✓	2 (2 × AO2.1)	**ALLOW** 2 marks for calculations to show this e.g. λ_A 0.55(m) **and** λ_B = 0.275(m) **ALLOW** a lower frequency/less waves per second means a longer wavelength / **ORA** Maximum of 1 mark if speed changes
			Total	**15**	