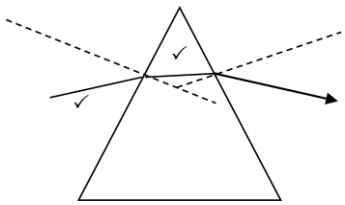
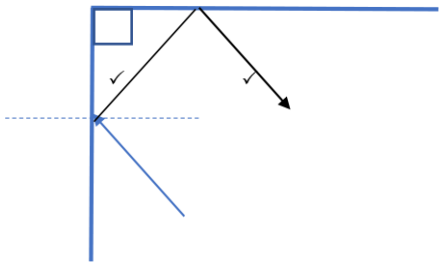
Mark scheme – Wave Behaviour (H)

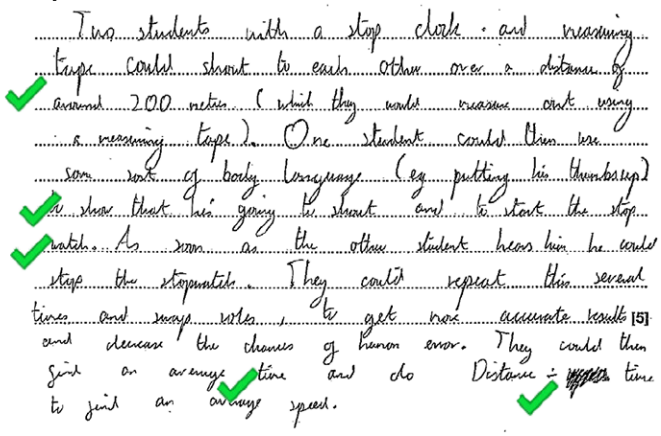
Question			Answer/Indicative content	Marks	Guidance
1	a		Ultrasound waves are <u>longitudinal</u> ✓ **OR** Ripples are <u>transverse</u> ✓ Oscillations/vibrations (of particles) in ultrasound/longitudinal waves are <u>parallel</u> to the direction of energy transfer / ultrasound has compressions and rarefactions ✓ **OR** Oscillations/vibrations (of particles) in the ripples/transverse waves are <u>perpendicular</u> to the direction of energy transfer ✓	2 (AO2 × 1.1)	**ALLOW** direction of travel/propagation for energy transfer **IGNORE** direction of wave motion
	b	i	0.0022 (m) ✓	1 (AO2.2)	
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 2.0 × 10^6 (Hz) award 4 marks** (Rearrange: frequency =) speed / wavelength **OR** (f =) 4500 / 0.0022 ✓ (f =) 2 045 455 (Hz) ✓ (f =) 2 000 000 (Hz) ✓ (f =) 2.0 × 10^6 (Hz) ✓	4 (AO1.2) (AO2 x 2.1) (AO1.2)	**ALLOW** ecf from **(i)** **ALLOW** three marks for 2.0 MHz **ALLOW** a mark for their answer to 2 significant figures **ALLOW** a mark for their answer in standard form
	c		Decreases ✓ Stays the same ✓	2 (AO2 × 2.1)	
	d	i	(Partial) reflection/absorption at the front of the kidney ✓ (Partial) reflection at the back of the kidney ✓	2 (AO2 × 2.1)	Both of the marking points can be awarded by a suitably clear diagram (or additional drawings on the given diagram) **ALLOW** 1 mark maximum for just reflection/bounces back
		ii	Measure the <u>time</u> between reflections ✓ Use distance = ½ x speed x time (to find the size) ✓	2 (AO2 × 2.2)	**ALLOW** distance = speed x time and mention of time halve
	e		There is no (known) risk associated with ultrasound / ultrasounds are safer than X-rays / X-rays pass through soft tissue	1 (AO1.1)	**ALLOW** X-rays used to detect bones/pass through kidney **ALLOW** ultrasound detects soft tissue/organs

			(so would not detect the kidney) / X-rays are ionising (radiation) ✓		
			Total	**14**	
2			**A** ✓	1 (AO1.1)	
			Total	**1**	
3			**A** ✓	1 (AO2.2)	
			Total	**1**	
4	a	i	Mean = (0.28 + 0.32) = 0.30 (s) ✓	1 (AO 1.2)	**ALLOW** 0.3 (s) **DO NOT ALLOW** answers with all 3 readings used giving a mean of (0.28+0.32+0.54) / 3 = 0.38 (s) **Examiner's Comments** **AfL** Candidates need to be aware that anomalous readings in a set of results, due to a mistake or lack of attention, are not included in calculations of the mean.
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 333 (m/s) award 4 marks** Use of distance = 100 m ✓ Recall (s =) d / t ✓ 100 / 0.3 ✓ (s =) 333 (m/s) (3 sig. figs.)✓	4 (AO 2.1) (AO 1.2) (AO 2.1) (AO 2.1)	**ALLOW ECF** from **24(a)(i)** **ALLOW** 100 ÷ 0.38 ✓✓✓ **ALLOW** 263 (m/s) ✓✓✓✓ **ALLOW** ECF for 3rd and 4th marking points if incorrect distance is used **ALLOW** 50 ÷ 0.3 or 166.7 ✓✓ **ALLOW** 50 ÷ 0.38 or 131.6 ✓✓ **ALLOW** 132 ✓✓✓ **ALLOW** 167 ✓✓✓ **Examiner's Comments** The majority of candidates could rearrange the equation provided, substitute values and give their answer to 3 significant figures. However, many candidates did not take into account that the sound travelled 100m to the wall and back again so used 50m in their calculations instead. **AfL**

					A number of candidates gave two possible versions of rearranging the equation leading to two different answers. Candidates should be aware that marks cannot be awarded when they do this, even if one of the versions is correct.
		iii	**Any two from:** Inconsistent results should be repeated ✓ More readings of time should be done and the mean calculated ✓ (Explanation of) clap-echo method ✓ Larger/different distances used ✓	2 (AO 2×3.3b)	Clap-echo method effectively may gain 2 marks as it also uses the idea of multiple readings. **Examiner's Comments** This Assessment Objective 3 question required candidates to analyse information in order to develop the experimental procedure of the students (in Question 24(a)). There is evidence that over half of the candidates did not read the question carefully as they suggested improvements relating to other methods such as videoing, using microphones etc. Many candidates suggested taking more readings but did not mention calculating the mean and therefore could not score the mark.
	b		idea of 3 echoes/reflections/returning pulses (from each pulse) / AW✓ takes different times to travel (there and back) through different layers/distances/thicknesses / time (interval) between echoes is different/not regular / AW ✓✓ **BUT** the thicker the layer/the longer the distance, the bigger the time interval/takes longer to travel (there and back) / AW ✓✓	3 (AO 3×2.1)	**ALLOW** (idea of measuring) the time taken for the wave to be reflected back (for different layers) **Examiner's Comments** This question assessed candidates' ability to apply their knowledge of ultrasound. It proved challenging to a number of candidates and about one third did not gain any credit. Candidates used their knowledge of ultrasound but often did not relate this to the question asked, or their answers were not specific enough e.g. the number of pulses shows that there are 3 layers of tissue.
			Total	**10**	
5	a		Diagram showing correct refractions  	2 (AO 2x1.2)	If diagram is incorrect, maximum of one mark from: any rising line in air before the prism ✓ a line in the prism close to horizontal by eye and joining the exit ray ✓ **IGNORE** any arrows on rays **Examiner's Comments** This question proved very difficult for most candidates. Although some candidates could accurately draw the ray of light as it travelled through the glass prism, only the more able gained 2 marks.

	b			2 (AO 2×1.2)	One mark for each correct reflection of about 90o by eye **IGNORE** any arrows on rays
			Total	**4**	
6			**B** ✓	1 (AO 1.1)	
			Total	**1**	
7			**D** ✓	1 (AO 2.2)	**Examiner's Comments** This question assessed candidates' knowledge of refraction of sound waves. Around a third of candidates did not know that a sound wave travels faster in water than air. **Misconception** Many candidates had the misconception that a sound wave slows down when it enters water and incorrectly chose option B.
			Total	**1**	
8			**A** ✓	1 (AO 1.2)	**Examiner's Comments** Most candidates successfully applied their knowledge of electromagnetic waves to identify that the energy transfer for row A was correct.
			Total	**1**	
9	a	i	2 ½ or 2.5 ✓	**1** (AO1.2)	**Examiner's Comments** Most candidates were able to calculate the number of waves produced. The most common error made was to divide the time by the frequency instead of multiplying the time by the frequency.
		ii	**Speed** is unchanged / stays the same ✓ **Wavelength** reduces ✓	**2** (AO2.1) (AO2.1)	Answer **must** indicate idea of speed Answer **must** indicate idea of wavelength **IGNORE** answers that merely state 'no change and reduces'

					Examiner's Comments Most candidates correctly stated that the wavelength would decrease. The majority of candidates stating that wave speed would also increase while only the highest ability candidates knew that that wave speed would be unchanged.
		iii	Any two from: Water / particles move up and down / oscillate vertically ✓ Water / particles move at 90° / perpendicular to the direction of wave (travel) / AW ✓ Energy moves in direction of the wave (travel) / AW ✓	**2** (AO2 × 2.1)	**IGNORE** any statements that are just repeated from the question. **IGNORE** water waves move up and down **ALLOW** energy moves at 90° to wave vibrations / movement ✓✓ **Examiner's Comments** Candidates found this question very challenging and many misinterpreted what they were being asked to do. Most candidates did not identify that the second and third statements about water wave were incorrect and many merely rewrote the student's original statement. The most common mark gained was for the idea of the water moving perpendicular to the direction of the wave motion. Only the highest ability candidates gained full credit.
	b		(Idea of) action to produce sound and seen by observer / received by receiver ✓ Measure an appropriate distance eg between source and observer or between microphone(s) / speaker ✓ Measure an appropriate time eg between seeing action and hearing sound or on CRO / or frequency from signal generator ✓ (Idea of) calculating speed = distance / time or velocity = frequency x wavelength ✓ (Idea of) improvements to experiment eg repeat **and** average readings / retake readings if they are anomalous / use a different method / use different equipment / use longer distances ✓	**5** (AO1.1) (AO2.2) (AO2.2) (AO3.2b) (AO3.3b)	**ALLOW** marks to be awarded from a clear diagram **ALLOW** higher level methods eg using standing waves **ALLOW** equation in any form **Examiner's Comments** This question assessed AO1, AO2 and AO3 and discriminated well between the lower and higher ability candidates. Many correct experiments were suggested, for example practical improvements to the ball being hit by a bat making use of echoes, microphones and oscilloscope, as well as less practical suggestions in a school setting involving the use of fireworks and explosions. Some candidates made vague references to 'using a computer' that could not be credited. Most candidates realised that it was necessary to measure a time, but did not clearly specify what time they should measure. Almost every candidate gained some credit, many

					for stating the correct equation to calculate speed or for the idea of taking multiple readings and then using the average value. **Exemplar 2**  Two students with a stop clock and measuring tape could shout to each other over a distance of around 200 metres (which they would measure out using a measuring tape). One student could then see some sort of body language (eg putting his thumbs up) to show that he is going to shout and to start the stop watch. As soon as the other student hears him he could stop the stopwatch. They could repeat this several times and swap roles, to get more accurate results [5] and decrease the chances of human error. They could then find an average time and do Distance ÷ ~~speed~~ time to find an average speed. This candidate gained full credit. The response included: • a suitable experiment • an appropriate time and distance measured • an equation to calculate the speed • the improvement of repeating and averaging the readings in order to improve accuracy and reduce the effect of operator error on their observations.
	c		**Any 3 from:** Outer ear (pinna) / auditory canal transfers sound to ear drum ✓ Ear drum vibrates ✓ Ossicles / small bones / anvil, hammer or stirrup vibrate ✓ Ossicles / small bones / anvil, hammer or stirrup amplify vibration ✓ Liquid in cochlea transmits movement (to small hairs) ✓ Small hairs / cilia vibrate ✓	**3** (AO1.1) (AO2 × 2.1)	**ALLOW** ear drum moves in and out **Examiner's Comments** Most candidates gained at least 1 mark for either the eardrum, ossicles or cilia vibrating. Good responses were able to mention all 3 of these vibrations. Candidates who achieved zero or 1 mark, did not use the word 'vibrate', merely listing the parts of the ear that the sound travelled through.
			Total	**13**	
10			**C** ✓	**1** **(AO1.2)**	
			Total	**1**	
11			**B** ✓	**1** **(AO2.2)**	**Examiner's Comments**

					Candidates found this question challenging and many candidates selected distractor A as their answer. **Key** **Misconception** Candidates knew that the ray should enter and leave the block in the same direction (options A and B). However, the ray is also refracted as it enters the glass block and this is independent of the angle of incidence. Therefore option B is the only correct answer.
			Total	**1**	