Question			Expected Answers	M	Additional Guidance
1					
	a		oscillation/vibration of <u>particles/medium</u> in direction of travel of the wave example: sound wave, etc. oscillation/vibration of <u>particles/medium</u> (in the plane) at right angles to direction of travel of the wave example: surface water waves, string, electromagnetic, etc	B1 B1 B1 B1	**allow** direction of energy transfer of the wave **not** direction of wave motion **allow** direction of energy transfer of the wave **allow** RE mark for weaker descriptions with same omissions as in longitudinal wave
	b		the incident wave is reflected at the end of the pipe <u>reflected</u> wave <u>interferes/superposes</u> with the incident wave to produce (a resultant wave with) nodes and/or antinodes	B1 B1 B1	 **QWC mark** **accept** resultant wave with no energy transfer
	c	**i**	at 0 oscillation with max amplitude along tube at 0.2 m (oscillation along tube with) smaller amplitude at 0.6 m no motion/node	B1 B1 	**not** displacement (penalise only once) all 4 correct for 2 marks; 2 correct for 1 mark
		ii	oscillation at 3 times the frequency of c(i) at 0 (oscillation with) max amplitude (along tube)/antinode at 0.2 m no motion/node at 0.4 m motion as at 0 (but in antiphase/opposite direction)	B1 B1 	 3 correct for 2 marks; 2 correct for 1 mark
	d	**i**	λ/2 sketch with zero at 0.3 m	M1 A1	**accept** 1 or 2 lines, solid or dotted
		ii	$2f_0$	B1	**no ecf from d(i)**
			Total question 6	**14**	

Question			Expected Answers	M	Additional Guidance
2					
	a	**i**	light emitted from (excited isolated) atoms produces a line spectrum a series of (sharp/bright/coloured) lines against a dark background	B1 B1	**max 2 marks** from 3 marking points
		ii	in an absorption spectrum a series of dark lines (appears against a bright background/within a continuous spectrum)	B1	**accept** black
	b	**i**	$\varepsilon = hc/\lambda$ $= 6.63 \times 10^{-34} \times 3.00 \times 10^{8} / 436 \times 10^{-9}$ $= 4.56 \times 10^{-19}$ (J)	C1 C1 A1	**apply** SF error if all numbers not to 3+ figures 4.54 if use 6.6
		ii	3.64×10^{-19} (J)	A1	**allow** mark if repeated error from **b(i)**
	c	**i**	correct vertical lines; correct labels arrow(s) downwards	B1 B1 B1	**1 mark** for 1 vertical line + correct label
		ii	- 8.86 + 4.56 = - 4.3 x 1 $^{-19}$ (J) - 7.94 + 3.64 = - 4.3 x 1 $^{-19}$ (J)	B1 B1	**ecf b(i)** **do** calculation for one line only correctly scores 2 marks; give answer as 4.3×10^{-19} **or** -4.3 scores 1 mark **do** calculation for both lines and give answer as 4.3×10^{-19} **or** -4.3 scores both marks
N.B. Before marking 7d check pages 18, 19 and 20 for additional answers by scrolling down. Extra answers MUST be annotated to show that they have been seen and credited back in the relevant question when appropriate. **✓ = 1 extra mark** **x = incorrect; scores 0** **NBOD = no added value or no further action needed; scores 0** **CON = if reference is made to the additional answer in the main text and this answer contradicts the other then deduct the original mark; = if NO reference is made to the additional answer in the main text and this answer contradicts the other then do NOT change the original mark**					
	d		$(d \sin\theta = \lambda)$ $3.3 \times 10^{-6} \sin\theta = 546 \times 10^{-9}$ $\sin\theta = 0.165$ $\theta = 9.5^{o}$	C1 C1 A1	
			Total question 7	**15**	

Question			Expected Answers	Marks	Additional Guidance
3	(a)	(i)	diffraction or refraction or superposition or interference	B2	**accept** any two from the four listed
		(ii)	only transverse waves can be polarised	B1	**accept** sound is a longitudinal wave or e-m waves are transverse
		(iii)	place transmitter and receiver facing each other	B1	**accept** from diagram **allow** (metal) grille/polarising filter to polarise microwaves
			rotate either transmitter or receiver through 90^o about axis joining aerials **or** use two polarising filters and rotate from parallel to crossed	B1	**accept** place (metal) grille/polarising filter [**not** Polaroid] between transmitter and receiver and rotate through 90^o
			observe signal fall to zero/minimum from initial high value on meter monitoring output of receiver	B1	
			explanation of observations/link between observations and polarisation	B1	QWC mark
	(b)	(i) 1	0.3 (mm)	B1	tolerance ±0.02 mm ie 0.28 – 0.32 (mm)
		2	T = 4.0 ms	C1	
			F = 1/T = 250 (Hz)	A1	**allow** 0.25 Hz or any other POT error for 1 mark
		(ii)	realisation that intensity is proportional to (amplitude)^2	B1	
			giving amplitude increase by $\sqrt{2}$, ie4(.2) mm	B1	
			sine wave of same frequency with any increased amplitude	B1	
		(iii)	microphone (to transfer mechanical motion to electrical signal/voltage)	B1	
			oscilloscope to display oscillation/wave for measurement (of period)/AW	B1	**accept** computer/datalogger/frequency meter with qualification as for oscilloscope
			Total question 4	**15**	