Question Number	Answer		Mark
15a	There is a decrease in speed/velocity	(1)	
	Part of the wavefront meets the boundary before the rest	(1)	
	(Ignore references to density and refractive index) (Allow MP2 for correct addition to the diagram by eye for wavefronts both before and after the boundary)		**(2)**
15bi	Use of $v = \sqrt{\frac{g\lambda}{2\pi}}$ to find speed in deep water	(1)	
	Use of $v = \sqrt{(gd)}$ to find speed in shallow water	(1)	
	Calculates ratio of speeds	(1)	
	Correctly equates ratio of speeds to ratio of sine of each angle	(1)	
	$r = 17°$	(1)	
	<u>Example of calculation</u> $v = \sqrt{\frac{g\lambda}{2\pi}} = \sqrt{\frac{(9.81 \text{ms}^{-2} \times 15 \text{ m})}{2\pi}} = 4.8 \text{ ms}^{-1}$ (deep water) $v = \sqrt{(gd)} = \sqrt{(9.81 \text{ ms}^{-2} \times 0.50 \text{ m})} = 2.2 \text{ ms}^{-1}$ (shallow water) ratio of speeds = (4.8 ms^{-1}) / (2.2 ms^{-1}) = 2.2 sin r = sin (40) / 2.2 = 0.29 $r = 17°$		**(5)**
15bii	Use of $f = 1/T$ and $v = f\lambda$ to find speed of wave	(1)	
	Use of $v = \sqrt{\frac{g\lambda}{2\pi}}$ to find same speed in deep water, confirming that deep water equation is the correct equation for this wave	(1)	
	Deep water equation only works if $d > 342 / 2$ so d must be > 171m	(1)	
	<u>Example of calculation</u> $f = 1 / 14.8 \text{ s} = 0.0676 \text{ Hz}$ $v = 0.0676 \text{ Hz} \times 342 \text{ m} = 23.1 \text{ ms}^{-1}$ $v = \sqrt{\frac{g\lambda}{2\pi}} = \sqrt{\frac{(9.81 \text{ms}^{-2} \times 342 \text{ m})}{2\pi}} = 23.1 \text{ ms}^{-1}$ (deep water)		**(3)**
	Total for question 15		**10**