

Question number	Answer	Notes	Marks
11 (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 = $\sin(\text{angle of incidence}) / \sin(\text{angle of refraction})$;	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.;	allow ecf from (ii)	2
	e.g. $n = \sin(64) / \sin(32)$ $n = 1.70$	allow 1.696...	
(v)	$\sin(c) = 1 / n$;	allow standard symbols and rearrangements	1
(vi)	substitution OR rearrangement; evaluation;	allow ecf from (iv)	2
	e.g. $\sin(c) = 1/1.7$ OR $c = \sin^{-1}(1/n)$ (c =) 36 (degrees)	allow 36.03...(degrees)	
(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 11 = 12 marks