

Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	$n = \frac{\sin \theta_1}{\sin \theta_2} \quad (1)$ $1.53 = \frac{\sin 36.0}{\sin \theta_2} \quad (1)$ $\theta_2 = 22.6^\circ \quad (1)$	3	Accept: 23, 22.59, 22.592 Accept: $\frac{n_2}{n_1} = \frac{\sin \theta_1}{\sin \theta_2} \quad (1)$ $\frac{1.53}{1} = \frac{\sin 36.0}{\sin \theta_2} \quad (1)$ $\theta_2 = 22.6^\circ \quad (1)$
		(ii)	$180 - 60 - [90 - 22.6] \quad (1)$ $ (= 52.6^\circ)$ $(90 - 52.6 = B)$ $B = 37.4^\circ \quad (1)$	2	Or consistent with (a)(i) Value must be given to 1 decimal place or consistent with the number of decimal places in answer to (a)(i)
	(b)	(i)	The angle of incidence that produces an angle of refraction of 90° .	1	Accept a description of the incident ray as an alternative to the word 'incidence'. Do not accept: The minimum angle of incidence that causes total internal reflection.
		(ii)	$\sin \theta_c = \frac{1}{n} \quad (1)$ $\sin \theta_c = \frac{1}{1.53} \quad (1)$ $\theta_c = 40.8^\circ \quad (1)$	3	Accept: 41, 40.81, 40.813

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11.	(c)		Emergent ray drawn at an angle greater than angle B (1) $\left(n = \frac{\sin \theta_1}{\sin \theta_2} \right)$ $1.53 = \frac{\sin \theta_1}{\sin 37.4} \quad (1)$ $(\theta_1 = 68.3^\circ)$ calculated angle correctly shown on diagram (1)	3	or consistent with (a)(ii) and/or (b)(ii) Accept: 68, 68.32, 68.324 Ignore any partially reflected rays. If (a)(ii) has a greater angle than (b)(ii) then the total internal reflection would be correct Internally reflected ray drawn (1) Angle of reflection approximately equal to angle B (1) Value for angle of reflection shown on diagram consistent with (a)(ii) (1) Ignore any further refraction at other glass-air boundaries.