

a) Zircon $n_1 = 1.923$ Air $n_2 = 1.000$

$$\sin \theta_c = \frac{n_2}{n_1}$$

$$\sin \theta_c = \frac{(1.000)}{(1.923)}$$

$$\theta_c = 31.3^\circ$$

b) Fluorite $n_1 = 1.434$ Air $n_2 = 1.000$

$$\sin \theta_c = \frac{(1.000)}{(1.434)}$$

$$\theta_c = 44.2^\circ$$

c) Ice $n_1 = 1.309$ Air $n_2 = 1.000$

$$\sin \theta_c = \frac{(1.000)}{(1.309)}$$

$$\theta_c = 49.8^\circ$$