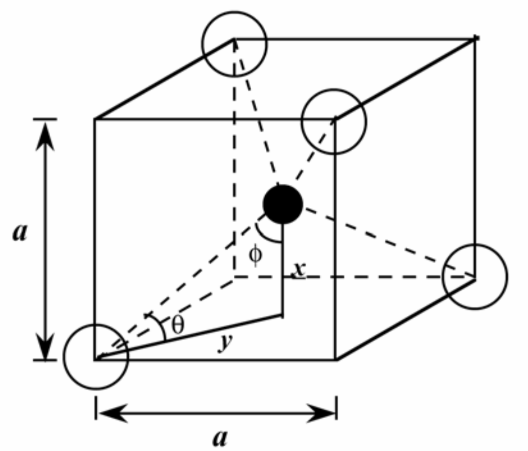
12.27 This problem asks for us to determine the angle between covalent bonds in the SiO_4^{4-} tetrahedron. Below is shown one such tetrahedron situated within a cube.



Now if we extend the base diagonal from one corner to the other, it is the case that

$$(2y)^2 = a^2 + a^2 = 2a^2$$

or

$$y = \frac{a\sqrt{2}}{2}$$

Furthermore, $x = a/2$, and

$$\tan\theta = \frac{x}{y} = \frac{a/2}{a\sqrt{2}/2} = \frac{1}{\sqrt{2}}$$

From which

$$\theta = \tan^{-1}\left(\frac{1}{\sqrt{2}}\right) = 35.26°$$

Now, solving for the angle ϕ

$$\phi = 180° - 90° - 35.26° = 54.74°$$

Finally, the bond angle is just 2ϕ, or $2\phi = (2)(54.74°) = 109.48°$.

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