1

Calculate the number density of atoms in the diamond cubic form of carbon (a literal diamond) and separately calculate the number density of atoms in silicon (which also has the diamond cubic crystal structure). The lattice parameter of diamond is 3.57 Angstroms (or 0.357 nm, or 0.357 x 10-9 m. The lattice parameter of silicon is 5.43 Angstroms (or 0.543 nm)

✓ **Answer**

8 atoms in diamond cubic structure.

$d = \frac{n}{V} = \frac{8}{V}$

Diamond

$d = \frac{8}{(3.57 \times 10^{-8} cm)^3} = 17.5 \times 10^{22}\ cm^{-3}$

Silicon

$d = \frac{8}{(5.43 \times 10^{-8} cm)^3} = 5.0 \times 10^{22}\ cm^{-3}$

Diamond has roughly 3x the number density of silicon.

2

Single crystals of sodium iodide (with low levels of thallium as a controlled impurity) are used as scintillation detectors for nuclear medicine. One manufacturer is Luxium Solutions in Hiram Ohio. On the datasheet (posted on Canvas or available at the botom of webpage at https://www.luxiumsolutions.com/radiation-detection-scintillators/crystal-scintillators/naitl-scintillation-crystals) you will find that they sell single crystals as large as 4”x4”x16”. Look up or calculate (in a manner analogous to Example Problem 3.7 in Callister and Rethwisch) the density of sodium iodide. Then, calculate and report the mass of these large rectangular blocks.

✓ **Answer**

$d = 3.67\ \frac{g}{cm^3}$ (from datasheet)
$V = 4 \times 4 \times 16\ in^3 = 256\ in^3 = 4195\ cm^3$
$m = d \times V = 15396.\ g = 15.4\ kg$

3

Also, on the Luxium datasheet for this material they report that the cleavage plane is <1 0 0>. This is a mistake in notation, it should say {1 0 0} for a family of planes, rather than <1 0 0> which is a family of directions. Sodium iodide is of the rock salt crystal structure which is Fig. 3.6 in Callister and Rethwisch. List all the member of the {100} family of planes for this structure.

✓ **Answer**

$[1\ 0\ 0]$, $[\bar{1}\ 0\ 0]$

4

As discussed in Section 4.6 of the book, polymer molecules are often coiled and have an effective length that is significantly shorter than would be true if they were stretched out. This arises from the ability of the covalent bonds along the chain length to rotate as is illustrated in Figure 4.5. For a linear, freely rotating polymer molecule, the total chain length, L, depends on the bond length between chain atoms, d, the total number of bonds in the molecule, N, and the angle between adjacent backbone chain atoms, θ, as follows:

$$L = Nd\sin\left(\frac{\theta}{2}\right)$$

But because of coiling the ends are actually much closer, the average end-to-end distance for a series of polymer molecules, r, in the figure below is given by

$$r = d\sqrt{N}$$

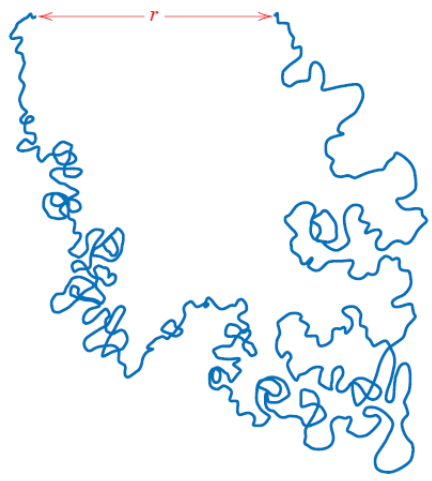


Figure 4.6 Schematic representation of a single polymer chain molecule that has numerous random kinks and coils produced by chain bond rotations.

Compute the values of L and r for a linear polyethylene with a number-average molecular weight average of 300,000 g/mol.

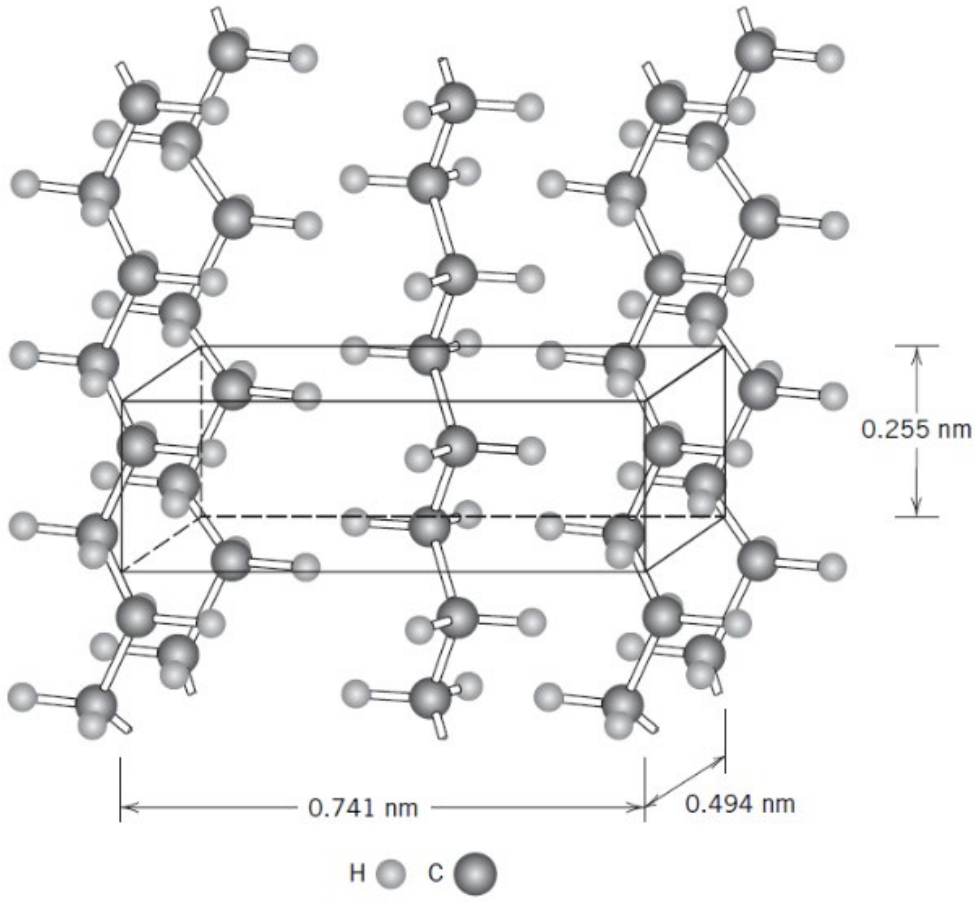
✓ **Answer**

$d = 0.154\ nm$ (searched up)
$\theta = 109^\circ$
$M_N = 300000\ \frac{g}{mol}$
$\frac{M_N}{m} = \frac{300000}{2(12.011)+4(1.0079)} = 10695$ (Number of units on a chain)
$L = Nd\sin\left(\frac{\theta}{2}\right) = 2 \times 10695 \times 0.154\sin(54.5^\circ)$
$L = 2682\ nm$

$r = d\sqrt{N} = 0.154\sqrt{2 \times 10695}$
$r = 22.5\ nm$

5

Shown below is the unit cell for crystalline polyethylene. Provide the name of the crystal system that it belongs to?



✓ **Answer**

Orthorhombic