14.10 (a) This portion of the problem asks for us to calculate the number-average molecular weight for a linear polytetrafluoroethylene for which L in Equation 14.11 is 2000 nm. It is first necessary to compute the value of N using this equation, where, for the C—C chain bond, d = 0.154 nm, and θ = 109°. Thus

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

$$= \frac{2000 \text{ nm}}{(0.154 \text{ nm}) \sin\left(\frac{109°}{2}\right)} = 15,900$$

Since there are two C—C bonds per PTFE repeat unit, there is an average of N/2 or 15,900/2 = 7950 repeat units per chain, which is also the degree of polymerization, DP. In order to compute the value of $\overline{M}_n$ using Equation 14.6, we must first determine m for PTFE. Each PTFE repeat unit consists of two carbon and four fluorine atoms, thus

$$m = 2(A_{\text{C}}) + 4(A_{\text{F}})$$

$$= (2)(12.01 \text{ g/mol}) + (4)(19.00 \text{ g/mol}) = 100.02 \text{ g/mol}$$

Therefore

$$\overline{M}_n = (DP)m = (7950)(100.02 \text{ g/mol}) = 795,000 \text{ g/mol}$$

(b) Next, we are to determine the number-average molecular weight for r = 15 nm. Solving for N from Equation 14.12 leads to

$$N = \frac{r^2}{d^2} = \frac{(15 \text{ nm})^2}{(0.154 \text{ nm})^2} = 9490$$

which is the total number of bonds per average molecule. Since there are two C—C bonds per repeat unit, then DP = N/2 = 9490/2 = 4745. Now, from Equation 14.6

$$\overline{M}_n = (DP)m = (4745)(100.02 \text{ g/mol}) = 474,600 \text{ g/mol}$$