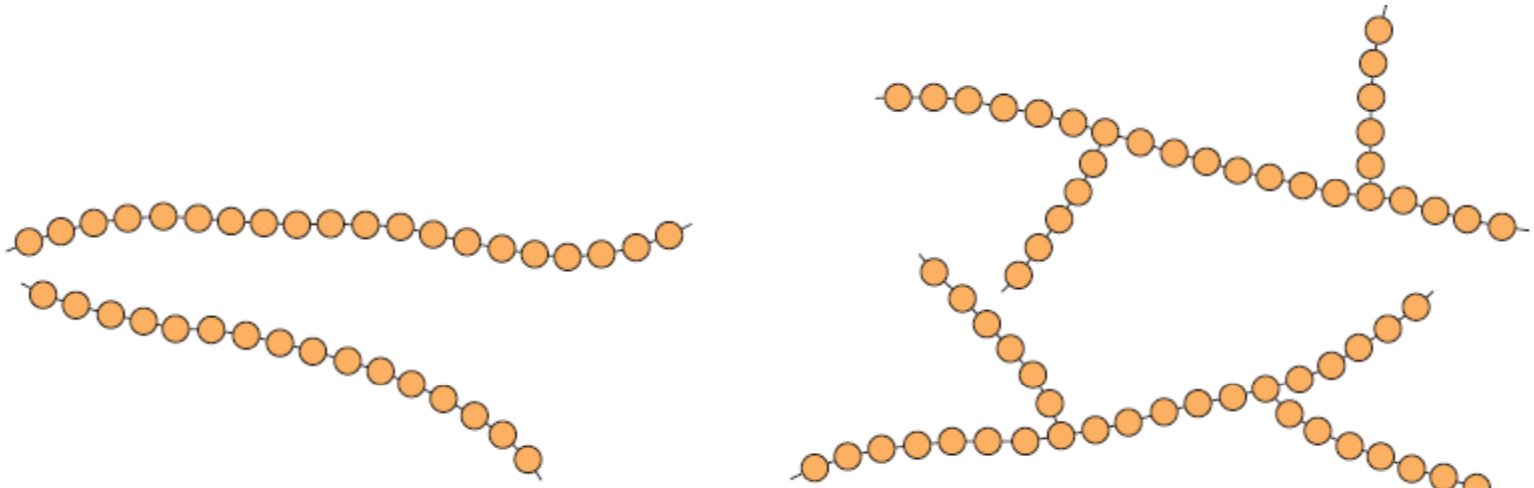
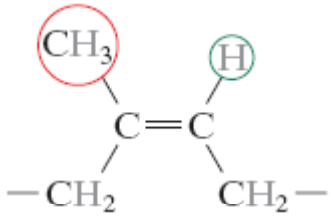
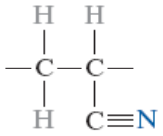


Chapter 14

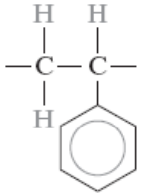


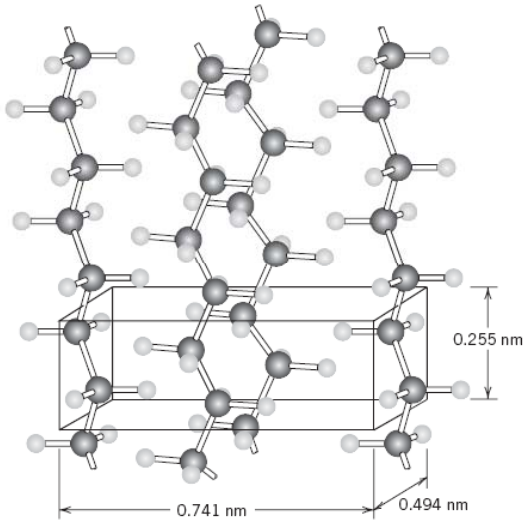
Polymers Tutorial

Acrylonitrile



Styrene





Concepts

NUMBER-AVERAGE MOLECULAR WEIGHT $\overline{M}_n$

$$\overline{M}_n = \Sigma x_i M_i$$

where

Mi : represents the **mean (middle) molecular weight** of size range i, and

Xi: is the **fraction of the total number of chains** within the corresponding size range.

WEIGHT-AVERAGE MOLECULAR WEIGHT $\overline{M}_w$

$$\overline{M}_w = \Sigma w_i M_i$$

Where

Mi :again, is the **mean molecular weight** within a size range, whereas

Wi :Denotes the **weight fraction** of molecules within the same size interval.

Degree of Polymerization (*DP)*

$$DP = \frac{\overline{M}_n}{m}$$

DP : is number-average molecular weight $\overline{Mn}$ by m,

where *m is the repeat unit molecular weight*.

14.5 Below, molecular weight data for a polytetrafluoroethylene material are tabulated. Compute **(a)** the number-average molecular weight, **(b)** the weight-average molecular weight, and **(c)** the degree of polymerization.

Molecular Weight Range (g/mol)	x_i	w_i
10,000–20,000	0.03	0.01
20,000–30,000	0.09	0.04
30,000–40,000	0.15	0.11
40,000–50,000	0.25	0.23
50,000–60,000	0.22	0.24
60,000–70,000	0.14	0.18
70,000–80,000	0.08	0.12
80,000–90,000	0.04	0.07

14.5 (a) From the tabulated data, we are asked to compute $\overline{M}_n$, the number-average molecular weight. This is carried out below.

Mean Molecular weight

Fraction of total no of chain, sum of xi=1

Molecular wt Range	Mean M_i	x_i	$x_i M_i$
10,000-20,000	15,000	0.03	450
20,000-30,000	25,000	0.09	2250
30,000-40,000	35,000	0.15	5250
40,000-50,000	45,000	0.25	11,250
50,000-60,000	55,000	0.22	12,100
60,000-70,000	65,000	0.14	9100
70,000-80,000	75,000	0.08	6000
80,000-90,000	85,000	0.04	3400

$$\overline{M}_n = \sum x_i M_i = 49{,}800 \text{ g/mol}$$

Number Average molecular weight

(b) From the tabulated data, we are asked to compute $\overline{M}_w$, the weight-average molecular weight.

weight fraction of molecular

Molecular wt. Range	Mean M_i	w_i	$w_i M_i$
10,000-20,000	15,000	0.01	150
20,000-30,000	25,000	0.04	1000
30,000-40,000	35,000	0.11	3850
40,000-50,000	45,000	0.23	10,350
50,000-60,000	55,000	0.24	13,200
60,000-70,000	65,000	0.18	11,700
70,000-80,000	75,000	0.12	9000
80,000-90,000	85,000	0.07	5950

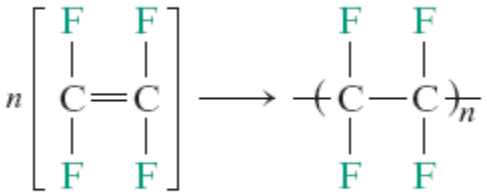
$$\overline{M}_w = \sum w_i M_i = 55{,}200 \text{ g/mol}$$

weight-average molecular weight.

(c) Now we are asked to compute the degree of polymerization, which is possible using Equation 14.6. For polytetrafluoroethylene, the repeat unit molecular weight is just

m= unit molecular weight

= 2*Atomic weight of C+4*Atomic weight of F



$$m = 2(A_C) + 4(A_F)$$

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

$$DP = \frac{\overline{M}_n}{m} = \frac{49{,}800\ \text{g/mol}}{100.02\ \text{g/mol}} = 498$$

Degree of Polymerization

14.6 Molecular weight data for some polymer are tabulated here. Compute **(a)** the number-average molecular weight, and **(b)** the weight-average molecular weight. **(c)** If it is known that this material's degree of polymerization is 477, which one of the polymers listed in Table 14.3 is this polymer? Why?

Molecular Weight Range (g/mol)	x_i	w_i
8,000–20,000	0.05	0.02
20,000–32,000	0.15	0.08
32,000–44,000	0.21	0.17
44,000–56,000	0.28	0.29
56,000–68,000	0.18	0.23
68,000–80,000	0.10	0.16
80,000–92,000	0.03	0.05

14.6 (a) From the tabulated data, we are asked to compute $\overline{M}_n$, the number-average molecular weight. This is carried out below.

Mean Molecular weight

Fraction of total no of chain, sum of xi=1

Molecular wt. Range	Mean M_i	x_i	$x_i M_i$
8,000-20,000	14,000	0.05	700
20,000-32,000	26,000	0.15	3900
32,000-44,000	38,000	0.21	7980
44,000-56,000	50,000	0.28	14,000
56,000-68,000	62,000	0.18	11,160
68,000-80,000	74,000	0.10	7400
80,000-92,000	86,000	0.03	2580

$$\overline{M}_n = \sum x_i M_i = 47,720 \text{ g/mol}$$

Number Average molecular weight

(b) From the tabulated data, we are asked to compute $\overline{M}_w$, the weight-average molecular weight. This determination is performed as follows:

weight fraction of molecular

Molecular wt. Range	Mean M_i	w_i	$w_i M_i$
8,000-20,000	14,000	0.02	280
20,000-32,000	26,000	0.08	2080
32,000-44,000	38,000	0.17	6460
44,000-56,000	50,000	0.29	14,500
56,000-68,000	62,000	0.23	14,260
68,000-80,000	74,000	0.16	11,840
80,000-92,000	86,000	0.05	4300

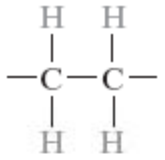
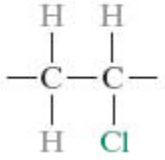
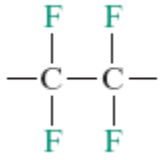
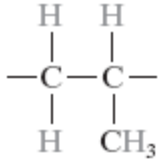
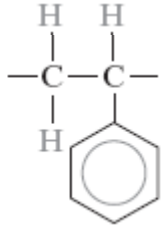
$$\overline{M}_w = \sum w_i M_i = 53,720 \text{ g/mol}$$

weight-average molecular weight.

(c) We are now asked if the degree of polymerization is 477, which of the polymers in Table 14.3 is this material? It is necessary to compute m in Equation 14.6 as

$$m = \frac{\overline{M}_n}{DP} = \frac{47{,}720 \text{ g/mol}}{477} = 100.04 \text{ g/mol}$$

Table 14.3 **A Listing of Repeat Units for 10 of the More Common Polymeric Materials**

Polymer	*Repeat Unit*
 Polyethylene (PE)	
 Poly(vinyl chloride) (PVC)	
 Polytetrafluoroethylene (PTFE)	
 Polypropylene (PP)	
 Polystyrene (PS)	

The repeat unit molecular weights of the polymers listed in Table 14.3 are as follows:

Polyethylene--28.05 g/mol

Poly(vinyl chloride)--62.49 g/mol

Polytetrafluoroethylene--100.02 g/mol

Polypropylene--42.08 g/mol

Polystyrene--104.14 g/mol

Poly(methyl methacrylate)--100.11 g/mol

Phenol-formaldehyde--133.16 g/mol

Nylon 6,6--226.32 g/mol

PET--192.16 g/mol

Polycarbonate--254.27 g/mol

Therefore, polytetrafluoroethylene is the material since its repeat unit molecular weight is closest to that calculated above.