

ENGG*2120 Fall 2011

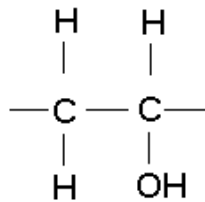
Chapter 14: Assignments with Answers

1. Sketch **repeat unit** structures for the following polymers: (a) poly (vinyl alcohol), (b) polyterafluroethylene, (c) polystyrene, (d) polyethylene (e) polypropylene **and** (f) polycarbonate.

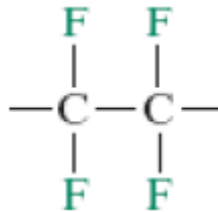
Answer:

The **repeat unit** structures are sketched below

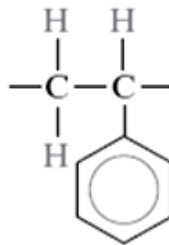
(a) Poly (vinyl alcohol)



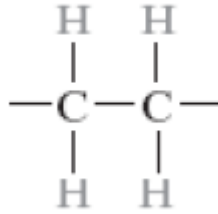
(b) Polytetrafluroethylene



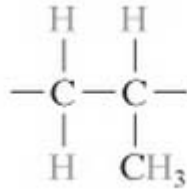
(c) Polystyrene



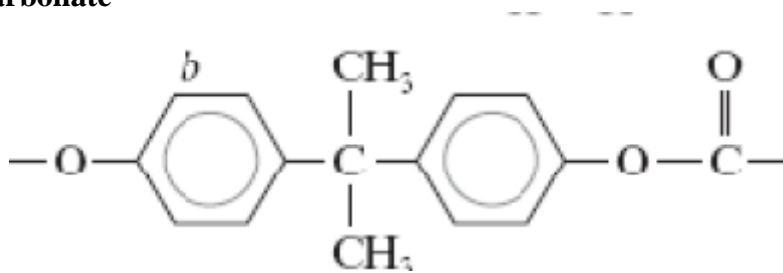
(d) Polyethylene



(e) Polypropylene



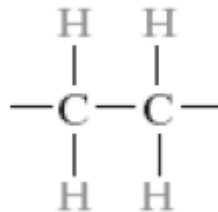
(f) Polycarbonate



2. Compute molecular weights for repeat unit of the following: (a) polyethylene, (b) poly(vinyl chloride), (c) nylon 6,6, and (d) poly(methyl methacrylate), (e) poly(vinyl alcohol).

Answer:

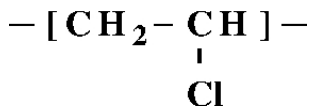
(a) Polyethylene



For polyethylene, each repeat unit consists of two carbons and four hydrogens. If A_C and A_H represent the atomic weights of carbon and hydrogen, respectively, then

$$\begin{aligned}
 m &= 2(A_C) + 4(A_H) \\
 &= (2)(12.01 \text{ g/mol}) + (4)(1.008 \text{ g/mol}) \\
 &= \mathbf{28.05 \text{ g/mol}}
 \end{aligned}$$

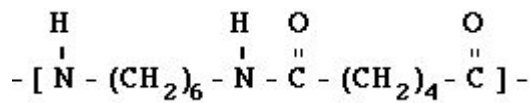
(b) Poly(vinyl chloride),



For poly(vinyl chloride), each repeat unit has two carbons, three hydrogen, and one chlorine. If A_C , A_H and A_{Cl} , represent the atomic weights of carbon, hydrogen and chlorine, respectively, then

$$\begin{aligned}
 m &= (2)(A_C) + (3)(A_H) + (1)(A_{Cl}) \\
 &= (2)(12.01 \text{ g/mol}) + (3)(1.008 \text{ g/mol}) + (1)(35.453 \text{ g/mol}) \\
 &= \mathbf{62.497 \text{ g/mol}}
 \end{aligned}$$

(c) Nylon 6,6,

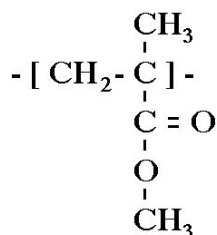


Repeating unit of Nylon 6,6

For nylon 6,6, each repeat unit has twelve carbons, twenty-two hydrogen's, two nitrogen's, and two oxygen's. Thus,

$$\begin{aligned}
 m &= 12(A_C) + 22(A_H) + 2(A_N) + 2(A_O) \\
 &= (12)(12.01 \text{ g/mol}) + (22)(1.008 \text{ g/mol}) + (2)(14.01 \text{ g/mol}) + (2)(16.00 \text{ g/mol}) \\
 &= \mathbf{226.32 \text{ g/mol}}
 \end{aligned}$$

(d) Poly(methyl methacrylate)

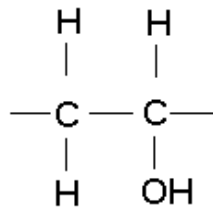


Repeating unit of Poly(methyl methacrylate)

For poly(methyl methacrylate), each repeat unit has 5 carbons, eight hydrogen's, and two oxygen's. Thus,

$$\begin{aligned}m &= 5(A_C) + 8(A_H) + 4(A_O) \\ &= (5)(12.01 \text{ g/mol}) + (8)(1.008 \text{ g/mol}) + (2)(16.00 \text{ g/mol}) \\ &= 100.114 \text{ g/mol}\end{aligned}$$

(e) Poly(vinyl alcohol),



Repeating unit of poly(vinyl alcohol)

For poly(vinyl alcohol), from, each repeat unit has two carbons, four hydrogen's, and one oxygen. If A_C , A_H and A_O , represent the atomic weights of carbon, hydrogen and oxygen, respectively, then

$$\begin{aligned}m &= 2(A_C) + 4(A_H) + 1(A_O) \\ &= 2* 12.01 \text{ g/mol} + 4*1.008 \text{ g/mol} + 1*16 \\ &= 44.05 \text{ g/mol}\end{aligned}$$

3. The number-average molecular weight of a polypropylene is 1,000,000 g/mol. Compute the degree of polymerization.

Answer:

Given that the number-average molecular weight is 1,000,000 g/mol.

The repeat unit molecular weight of polypropylene is

$$m = 3(A_C) + 6(A_H)$$

$$= (3)(12.01 \text{ g/mol}) + (6)(1.008 \text{ g/mol}) = 42.08 \text{ g/mol}$$

Now it is possible to compute the degree of polymerization using

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

$$DP = \frac{\bar{M}_n}{m} = \frac{1,000,000 \text{ g/mol}}{42.08 \text{ g/mol}} = 23,760$$

4. Compute the number-average molecular weight for polystyrene for which the degree of polymerization is 25,000.

Answer:

The repeat unit molecular weight of polystyrene is called for in this portion of the problem. For polystyrene each repeat unit has eight carbons and eight hydrogens. Thus,

$$m = 8(A_C) + 8(A_H)$$

$$= (8)(12.01 \text{ g/mol}) + (8)(1.008 \text{ g/mol}) = 104.14 \text{ g/mol}$$

The number-average molecular weight of polymer is given by equation

$$\bar{M}_n = (DP)m$$

Since the degree of polymerization is 25,000

$$\bar{M}_n = (DP)m = (25,000)(104.14 \text{ g/mol}) = 2.60 \times 10^6 \text{ g/mol}$$

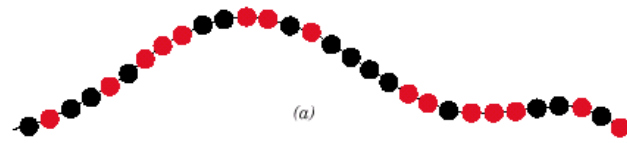
5. State the four types of copolymers and sketch their structures

Answer:

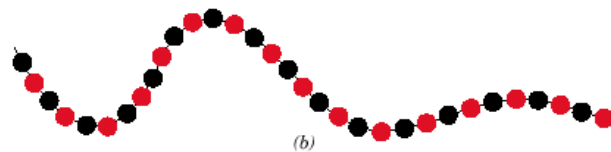
- Copolymers: two or more monomers polymerized together
- **Random** – A and B randomly vary in chain

- **Alternating** – A and B alternate in polymer chain
- **Block** – large blocks of A alternate with large blocks of B
- **Graft** – chains of B grafted on to A backbone

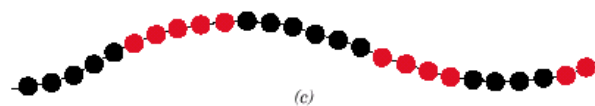
A – ● B – ●



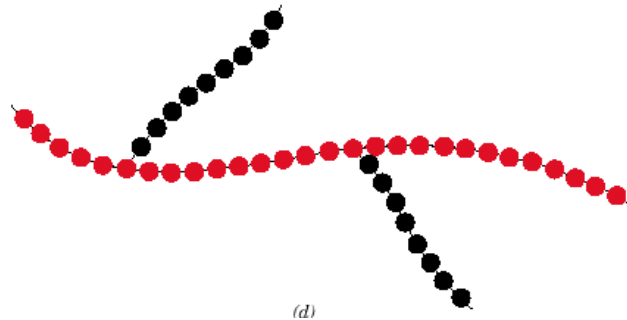
Random



Alternating



Block



Graft

6. Below, molecular weight data for a polypropylene 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
8,000–16,000	0.05	0.02
16,000–24,000	0.16	0.10
24,000–32,000	0.24	0.20

32,000–40,000	0.28	0.30
40,000–48,000	0.20	0.27
48,000–56,000	0.07	0.11

Answer:

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

Molecular wt Range	Mean M_i	x_i	$x_i M_i$
8,000-16,000	12,000	0.05	600
16,000-24,000	20,000	0.16	3200
24,000-32,000	28,000	0.24	6720
32,000-40,000	36,000	0.28	10,080
40,000-48,000	44,000	0.20	8800
48,000-56,000	52,000	0.07	3640

$$\bar{M}_n = \sum x_i M_i = 33,040 \text{ g/mol}$$

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

Molecular wt. Range	Mean	w_i	$w_i M_i$
8,000-16,000	12,000	0.02	240
16,000-24,000	20,000	0.10	2000
24,000-32,000	28,000	0.20	5600
32,000-40,000	36,000	0.30	10,800
40,000-48,000	44,000	0.27	11,880
48,000-56,000	52,000	0.11	5720

$$\bar{M}_w = \sum w_i M_i = 36,240 \text{ g/mol}$$

(c) Now we are asked to compute the degree of polymerization, which is possible using equation $DP = \frac{\bar{M}_n}{m}$.

For polypropylene, the repeat unit molecular weight is just

$$m = 3(A_C) + 6(A_H) \\ = (3)(12.01 \text{ g/mol}) + (6)(1.008 \text{ g/mol}) = 42.08 \text{ g/mol}$$

And

$$DP = \frac{\bar{M}_n}{m} = \frac{33,040 \text{ g/mol}}{42.08 \text{ g/mol}} = 785$$

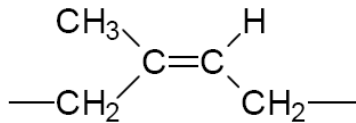
7. In your own words, briefly describe the

- (a) Cis isomerism
- (b) Trans isomerism

Answer:

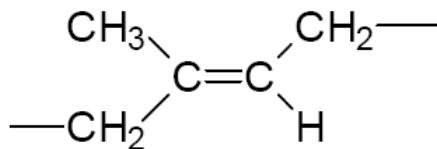
(a) Cis isomerism

Bulky groups are on the same side of chain



(b) Trans isomerism

Bulky groups are on the opposite side of chain



8. How are the densities of crystalline and amorphous polymers of the same material and having identical molecular weights compare? (Choose from one of following)

A. Density of crystalline polymer < Density of amorphous polymer

B. Density of crystalline polymer = Density of amorphous polymer

C. Density of crystalline polymer > Density of amorphous polymer

Answer: A

9. An isotactic polymer has R groups on the _____ of chain.

Answer:

Same side

10. Isomersim is the phenomenon observed for the hydrocarbon compounds with same composition and _____ arrangements.

Answer:

different atomic

11. Free radical polymerization has three steps initiation, _____ and _____

Answer:

propagation and termination

12. State True or False

Tensile strength of polymers often increases with crystallinity.

(_____)

Answer:

True

13. Explain briefly why the tendency of a polymer to crystallize decreases with increasing molecular weight.

Answer:

The tendency of a polymer to crystallize decreases with increasing molecular weight because as the chains become longer it is more difficult for all regions along the adjacent chains to align so as to produce the ordered atomic array.