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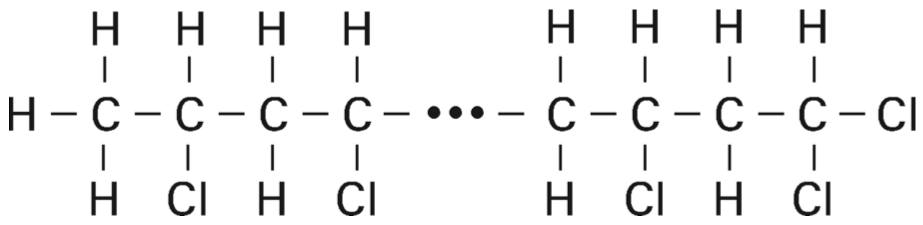
Chapter 31. Engineering Materials

Practice Problems

1.

Approximately how much (in molecules of HCl per gram of PVC) HCl should be used as an initiator in PVC if the efficiency is 20% and an average molecular weight of 7000 g/mol is desired? The final polymer has the structure shown.



(A)

7.8×10^{18} molecules HCl/gram PVC

(B)

4.3×10^{20} molecules HCl/gram PVC

(C)

9.5×10^{21} molecules HCl/gram PVC

(D)

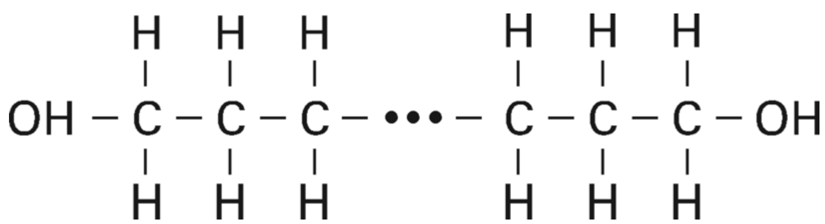
3.6×10^{23} molecules HCl/gram PVC

2.

10 ml of a 0.2% solution (by weight) of hydrogen peroxide is added to 12 g of ethylene to stabilize the polymer. Hydrogen peroxide breaks down according to

$$H_2O_2 \rightarrow 2\left(OH^-\right) + \cdots$$

Assume that the stabilized polymer has the structure shown.



What is most nearly the average degree of polymerization if the hydrogen peroxide is completely utilized?

(A)

180

(B)

730

(C)

910

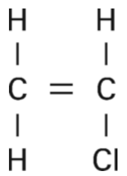
(D)

1200

Solutions

1.

The vinyl chloride mer is



With 20% efficiency, 5 molecules of HCl per PVC molecule are required to supply each end Cl atom. This is the same as 5 mol HCl per mole PVC. Using Avogadro's number of 6.022×10^{23} molecules per mole from *NCEES Handbook* table "Physical Constants," the number of molecules of HCl per gram of PVC is

$$\frac{\left(5\ \frac{\text{mol HCl}}{\text{mol PVC}}\right)\left(6.022 \times 10^{23}\ \frac{\text{molecules}}{\text{mol}}\right)}{7000\ \frac{\text{g}}{\text{mol}}} = 4.3 \times 10^{20}\ \text{molecules HCl/gram PVC}$$

The answer is (B).

2.

As in *NCEES Handbook:* Relative Atomic Mass, the molecular weight of hydrogen peroxide, H_2O_2, is

$$(2)\left(1\ \frac{\text{g}}{\text{mol}}\right) + (2)\left(16\ \frac{\text{g}}{\text{mol}}\right) = 34\ \text{g/mol}$$

The weight of H_2O_2 is

$$(10\ \text{mL})\left(1\ \frac{\text{g}}{\text{mL}}\right) = 10\ \text{g}$$

From *NCEES Handbook* table "Physical Constants," the number of H_2O_2 molecules in a 0.2% solution is

$$\frac{(10\ \text{g})\left(\frac{0.2\%}{100\%}\right)\left(6.022 \times 10^{23}\ \frac{\text{molecules}}{\text{mol}}\right)}{34\ \frac{\text{g}}{\text{mol}}} = 3.54 \times 10^{20}\ \text{molecules}$$

The molecular weight of ethylene, C_2H_4, is

$$(2)\left(12\ \frac{\text{g}}{\text{mol}}\right) + (4)\left(1\ \frac{\text{g}}{\text{mol}}\right) = 28\ \text{g/mol}$$

The number of ethylene molecules is

$$\frac{(12\ \text{g})\left(6.022\times 10^{23}\ \dfrac{\text{molecules}}{\text{mol}}\right)}{28\ \dfrac{\text{g}}{\text{mol}}}$$
$$= 2.58\times 10^{23}\ \text{molecules}$$

Since it takes one H_2O_2 molecule (i.e., $2OH^-$ radicals) to stabilize a polyethylene molecule, there are 3.54×10^{20} polymers.

The degree of polymerization is

$$\text{DP} = \frac{2.58\times 10^{23}\ \text{C}_2\text{H}_4\ \text{molecules}}{3.54\times 10^{20}\ \text{polymers}} = 729 \quad (730)$$

The answer is (B).