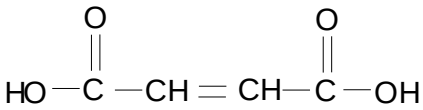
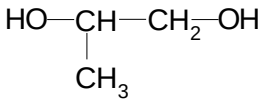
Solution for homework problems in chapter 2

Question 1 *Show the chemical reaction that forms a polyester made of maleic acid and propylene glycol. Show also the chemical reaction for crosslinking using styrene.*

The chemical formula for maleic acid is:



The chemical formula for propylene glycol is:

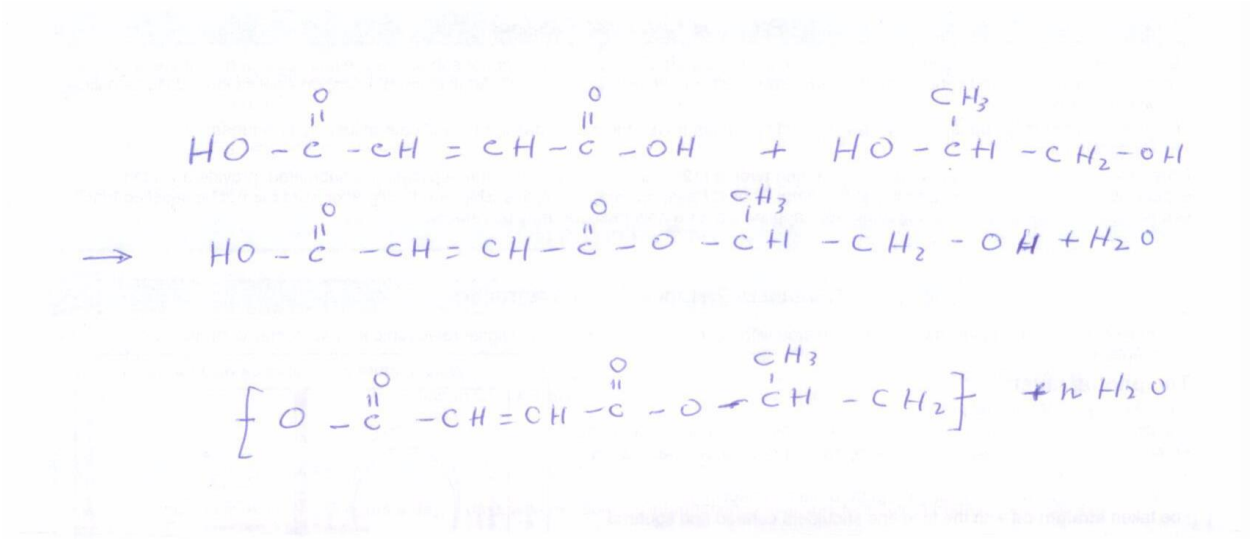


When the two molecules are placed close to each other, the end group will react as follows:

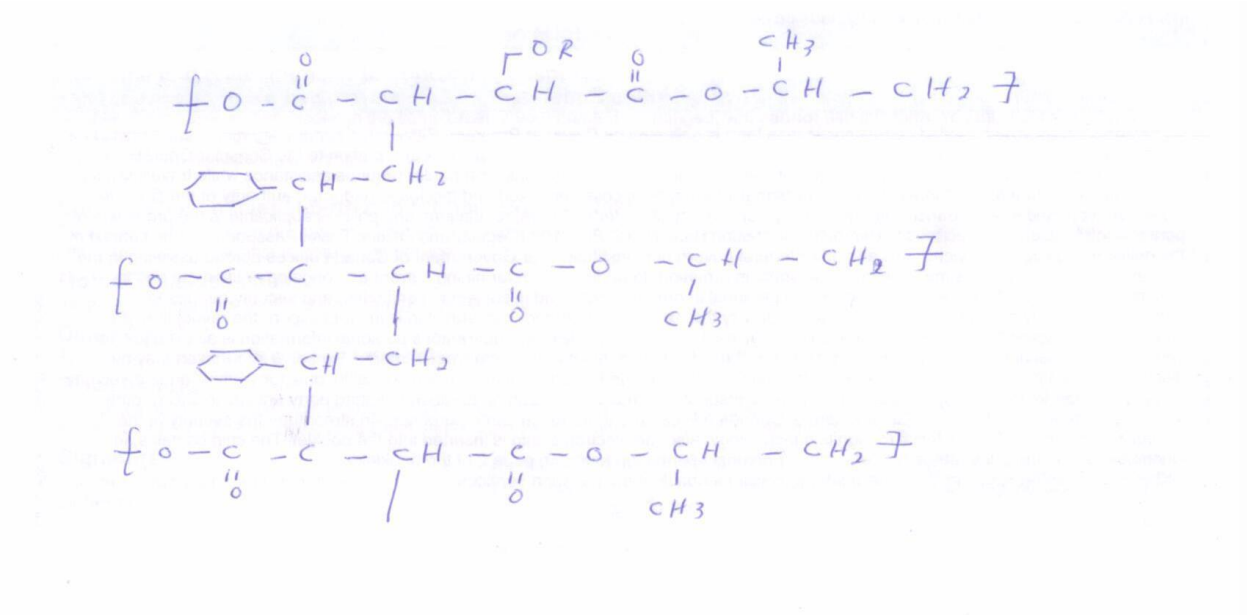
The end result is:

Cross linking using styrene:

Two units of the polyester and an initiator is shown below:



With the presence of three styrene molecules, one on top, one at the bottom, and one in between the two units of polyester, connection is made as follows:



Question 2 *It is desired to make a polyester using 100g of maleic acid and propylene glycol. A stoichiometric amount of propylene glycol is used. Cross linking is done using styrene.*

a) *After the condensate is removed, how many grams of polyester is obtained?*

b) *How much heat is generated?*

a. **Amount of polyester obtained**:

Consider the configuration as shown in question 1. It can be seen that one molecule of maleic acid reacting with one molecule of propylene glycol results in one unit of polyester and two water molecules.

Mass of one maleic acid molecule: 4C+4O + 4 H = 4(12) + 4(16) + 4(1) = 116 g/mole

Mass of one propylene molecule: 2C + 2O + 8H = 2(12) + 2(16) + 8(1) = 64 g/mole

Mass of one polyester unit: 6C + 4O + 8H = 6(12) + 4(16) + 8(1) = 144 g/mole

Since one uses 100 g of maleic acid, using proportionality, the amount of polyester obtained is:

X = (100g) [144/116] = 124.1g

b. Heat generated:

It can be seen that two units of polyester would correspond to 8 C-C bonds and 4 C=C bonds. As such one unit of polyester would correspond to 4 C-C bonds and 2 C=C bonds.

The energy associated with the bonds are:

C-C bond: 370 KJ/mole

C=C bond: 680 KJ/mole

One mole of polyester would correspond to 4 moles of C-C bonds and 2 moles of C=C bonds.

The energies associated with one mole of polyester are:

Breaking C=C bonds 2(680 KJ) = 1360 KJ (heat coming into the system)

Forming C-C bonds: 4(370 KJ) = 1480 KJ (heat coming out of the system)

The net heat coming out of the system, corresponding to 1 mole of polyester is:

1480 KJ – 1360 KJ = 120 KJ

The number of moles of polyester:

124.1/144 = 0.862 moles.

Total amount of heat generated:

(0.862) (120 KJ) = 103.4 KJ