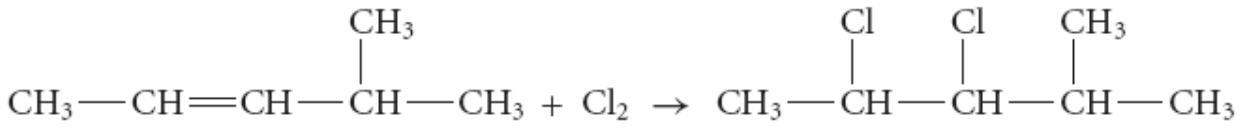
Unit 7 Chemical Changes of Organic Compounds
Chapter 15 Reactions of Organic Compounds
Solutions to Practice Problems

1.
Problem
Identify each reaction as an addition, a substitution, an elimination, or an esterification reaction:
a)



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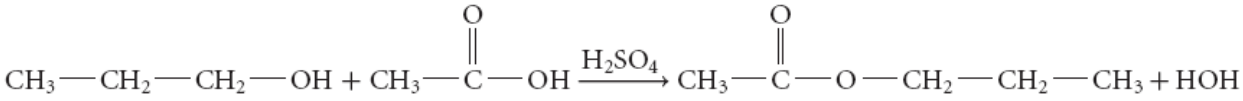

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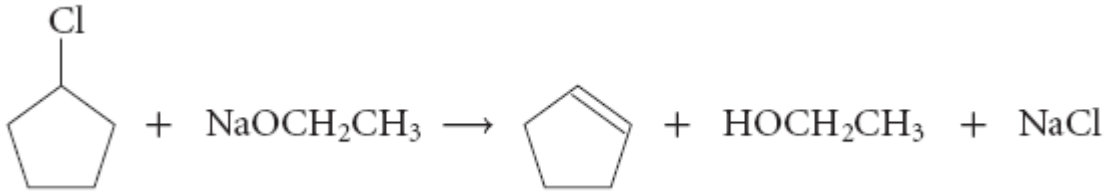


Solution
a) 4-methyl-pent-2-ene + chlorine gas → 2,3-dichloro-4-methylpentane
$Cl_2(g)$ adds at the double bond in a branched alkene to form a branched derivative of an alkane. This is an addition reaction.
b) propan-1-ol + ethanoic acid → propyl ethanoate + water
An alcohol reacts with a carboxylic acid to from an ester. This is an esterification reaction.
c) butane + bromine gas → 2-bromobutane + hydrogen bromide
A bromine atom replaces a hydrogen atom on the butane molecule. This is a substitution reaction.
d) chlorocyclopentane → cyclopentene + ethanol + sodium chloride
A chlorine atom is removed from the chlorocyclopentane and a double bond forms at the reaction site. This is an elimination reaction.

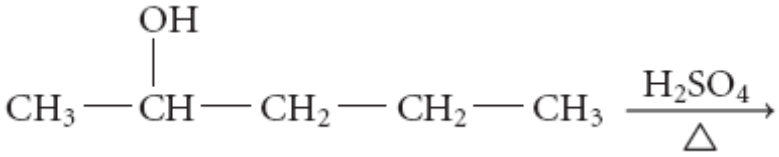
Check Your Solution
Each reaction matches with its correct definition.

2.

Problem

Complete the equations given on the next page. Draw structural formulas for the missing organic compounds. Name all reactants and products:

a)



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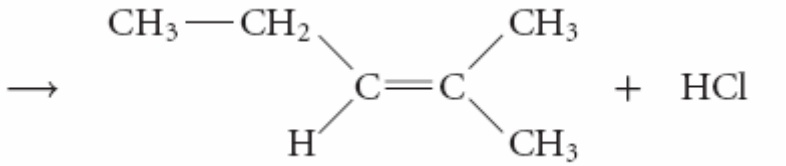

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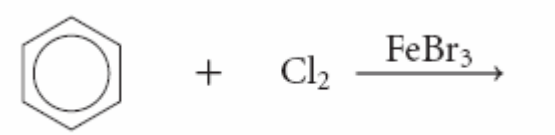

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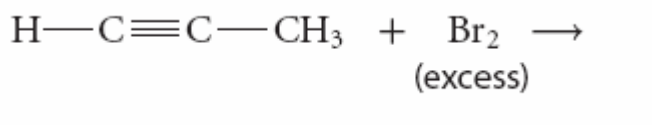

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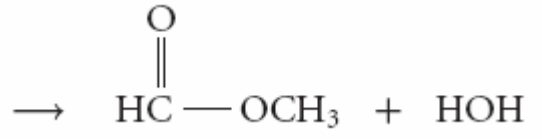

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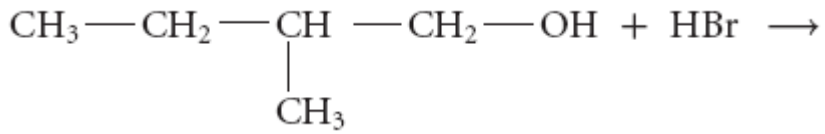
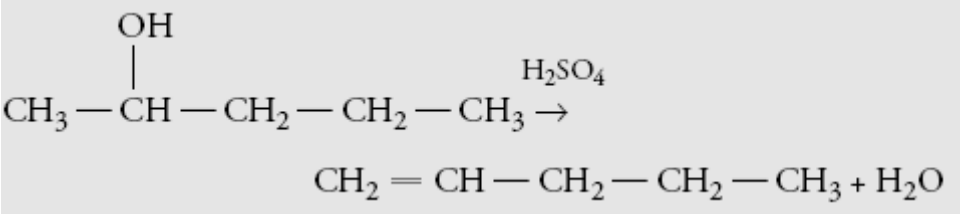
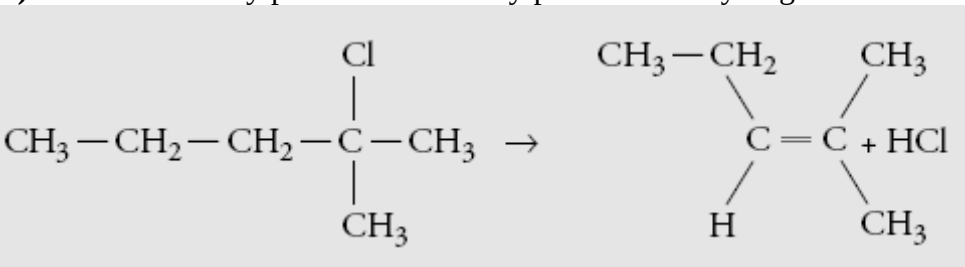


Solution

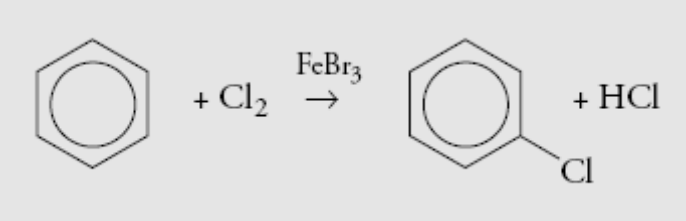
a) pentan-2-ol $\xrightarrow{H_2SO_4}$ pent-1-ene + water



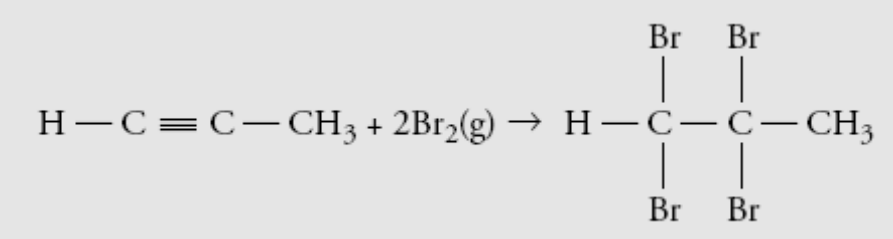
b) 2-chloro-2-methylpentane → 2-methylpent-2-ene + hydrogen chloride



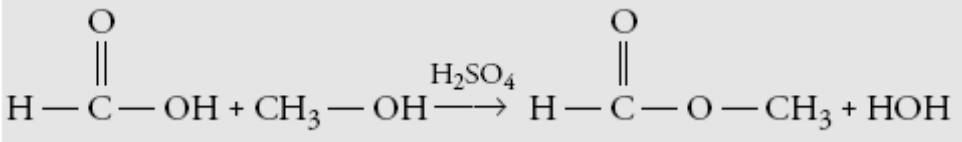
c) benzene + chlorine gas $\xrightarrow{FeBr_3}$ chlorobenzene + hydrogen chloride



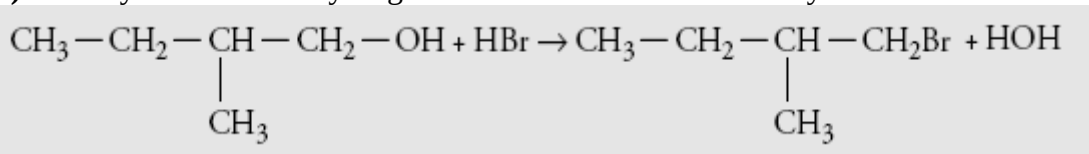
d) propyne + bromine gas (excess) → 1,1,2,2-tetrabromopropane



e) methanol + methanoic acid → methyl methanoate + water



f) 2-methylbutan-1-ol + hydrogen bromide → 1-bromo-2-methylbutane + water



Check Your Solution
The rules for naming organic molecules have been followed correctly.

3.
Problem
Identify each type of reaction in the previous question.

Solution
a) H and OH have been removed from 2-propanol. This is an elimination reaction.
b) H and Cl have been removed from 2-methylpent-2-ene. This is an elimination reaction.
c) H has been replaced with Cl on a benzene ring. This is a substitution reaction.
d) Br has been added at the triple bond in propyne. This is an addition reaction.
e) The product is an ester. This is an esterification reaction.
f) OH on 2-methylbutan-1-ol has been replaced with Br. This is a substitution reaction.

Check Your Solution
Each structure matches the correct name for each compound and the types of reaction match the definition.

4.
Problem
Write a balanced equation to show how you would form propan-2-ol from an alkene.

Solution
Prop-1-ene + water→ propan-2-ol

$CH_2{=}CH{-}CH_3 + HOH \rightarrow CH_3{-}CH(OH){-}CH_3$

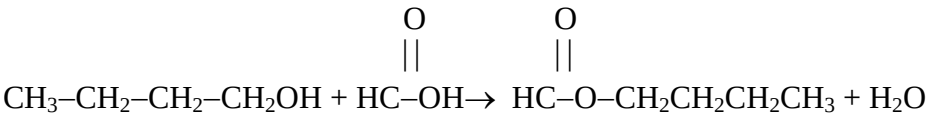
Check Your Solution
Markovnikov's rule predicts that the OH from water will add to the second carbon in propene.

5.
Problem
What series of reactions would you carry out to produce butyl methanoate from 1-chlorobutane? What carboxylic acid would you use? Write a balanced equation for each step.

Solution
The final product is an ester, butyl methanoate. To obtain this ester, butan-1-ol and methanoic acid must react.
Step 1: An alkyl halide will react with a strong base $OH^-(aq)$ at room temperature to produce an alcohol, in a substitution reaction. Butan-1-ol can be made from 1-chlorobutane in this manner.

$CH_3{-}CH_2{-}CH_2{-}CH_2Cl + OH^-(aq) \rightarrow CH_3{-}CH_2{-}CH_2{-}CH_2OH + Cl^-$

Step 2: Methanoic acid will react with the butan-1-ol to form butyl methanoate and water.



Check Your Solution
The equation is balanced and the structures correctly match the names.

6.
Problem
How could you convert 3-chloro-3-methylpentane into 3-methylpentan-3-ol? Write a balanced equation.

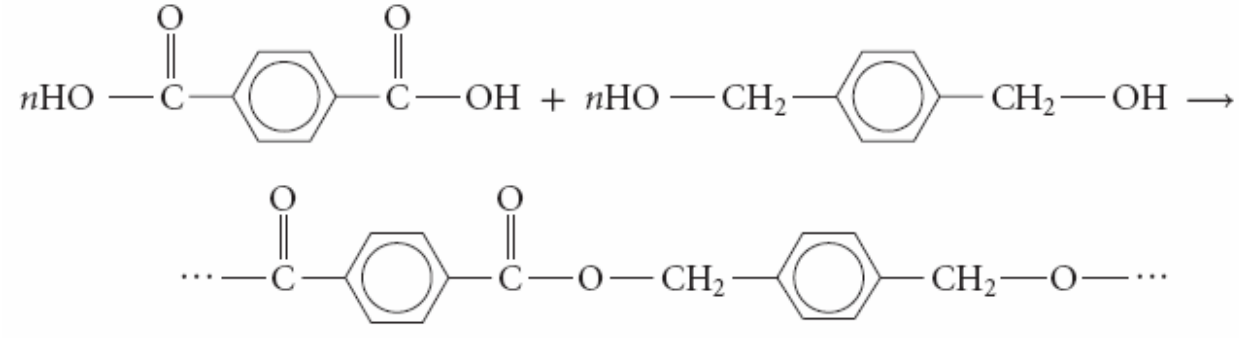
Solution
This reaction can be carried out in one step with a substitution reaction in the presence of a strong base.

3-chloro-3-methylpentane + $OH^-(aq) \rightarrow$ 3-methylpentan-3-ol + $Cl^-(aq)$

7.
Problem
A monomer called methylmethacrylate polymerizes to form an addition polymer that is used to make bowling balls. What is the name of this polymer?

Solution
The name of the polymer is based on the name of the monomer. The polymer is polymethylmethacrylate (commonly known as PMMA).

8.
Problem
Classify each of the following polymerization reactions as either an addition or a condensation polymerization reaction:
a)



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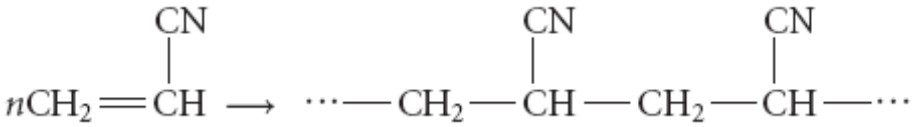

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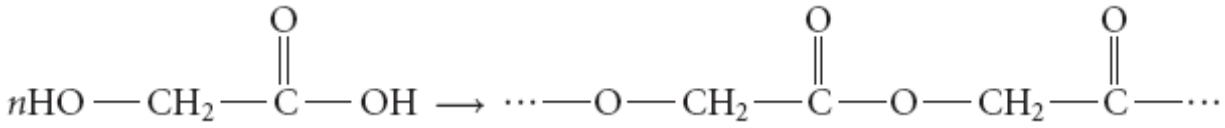


Solution

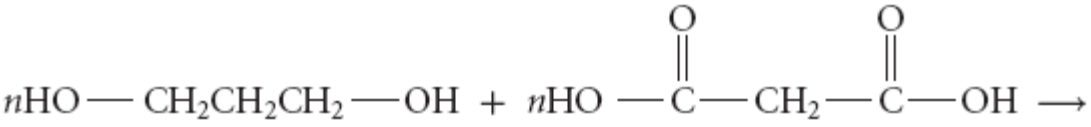
a) Ester bonds are formed between monomers. This is a condensation polymerization.
b) The reactant has a double bond, while the product does not. Therefore, this is an addition polymerization.
c) Ester bonds are formed between monomers. This is a condensation polymerization.

9.

Problem

Draw the product of each polymerization reaction. Include at least two linkages for each product.

a)



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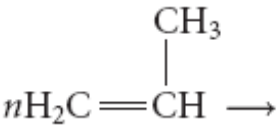

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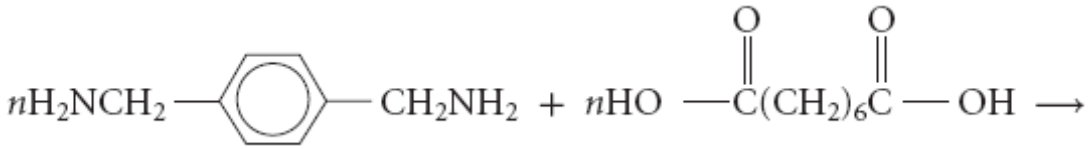
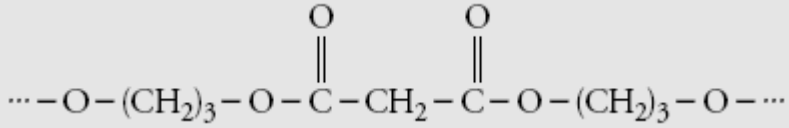


Solution

a)



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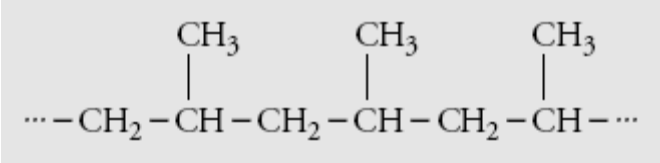

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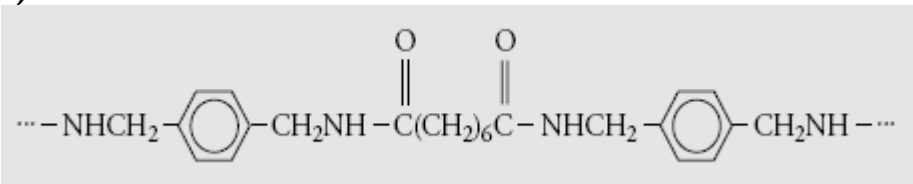
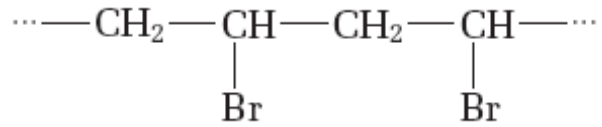


10.

Problem

Classify each polymer as an addition polymer or a condensation polymer. Then classify each condensation polymer as either a polyester or a polyamide:

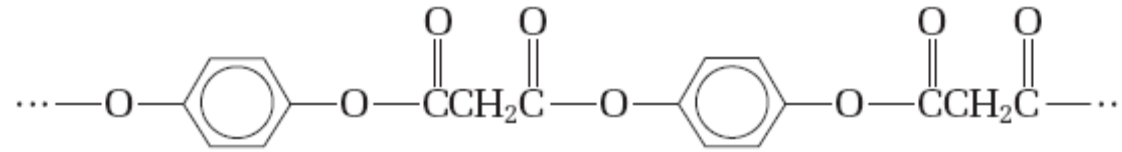
a)



b)

c)

d)



Solution

a) The polymer has a backbone of carbon atoms, with no ester or amide bonds. This is an addition polymer.

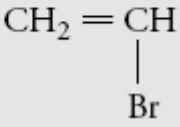
b) The polymer has amide bonds in the main chain. This was formed by condensation polymerization. It is a condensation polymer, and it is a polyamide, or nylon.

c) The polymer has ester bonds in the main chain. This is a condensation polymer and a polyester.
d) The polymer has ester bonds in the main chain. This is a condensation polymer and a polyester.

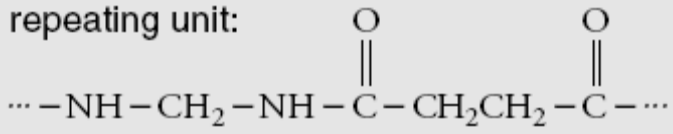
11.
Problem
Draw the structure of the repeating unit for each polymer in the previous question. Then draw the structure of the monomer(s) used to prepare each polymer.

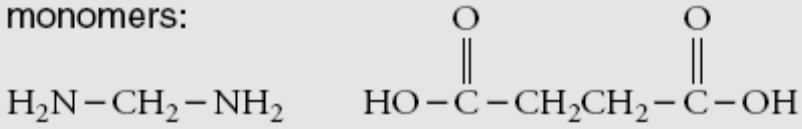
Solution
a)

repeating unit:

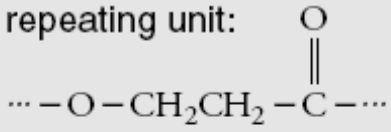
monomer: 

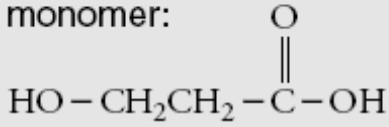
b)

repeating unit: 

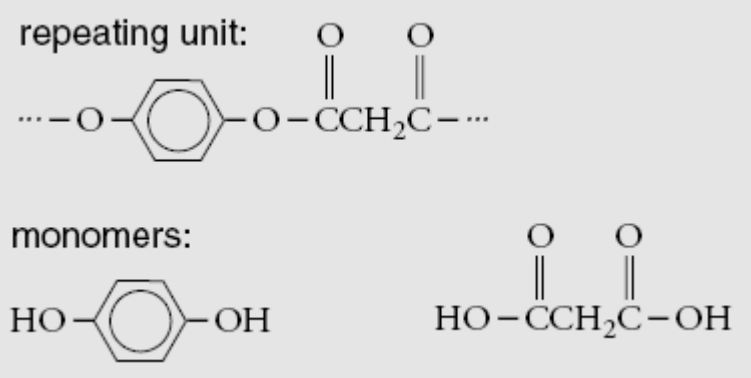
monomers: 

c)

repeating unit: 

monomer: 

d)



12.
Problem
How could you convert 1-bromoethane into polyethene? Write an equation for each step.

Solution
Step 1 To produce ethene, C_2H_4, heat an alkyl halide in the presence of a strong base, such as sodium ethoxide, $NaOCH_2CH_3(aq)$, mixed with an ethanol solvent.

$$CH_3–CH_2Br \xrightarrow{NaOCH_2CH_3} CH_2=CH_2 + H_2O + Br^-$$

Step 2 The monomer reactant is ethene, C_2H_4, and contains a double bond. The product polymer, polyethene, does not have a double bond, so an addition polymerization has to occur. Ethene reacts at high temperature and high pressure to polymerize and form polyethene.