Welcome to Chemistry 154!

Chemistry for Engineering

Reminders

- **Worksheet: Unit 5 Part 1 (questions 1-6)**
  Due Oct. ~~18~~ 19th at 11:59pm

- **Worksheet: Unit 5 Part 2 (questions 7-13)**
  Due Oct. 25th at 11:59pm

- **Achieve Assignment #5** (Due Oct. 25th at 11:59pm)

- **Chapter 5 videos on All Lectures site**

Videos 1 and 2: summarizes the main content of Unit 5

Videos 3-10: interactive videos on polymers

Instructor Office Hours

Monday and Friday 7-8pm via Zoom (All Lectures Site)

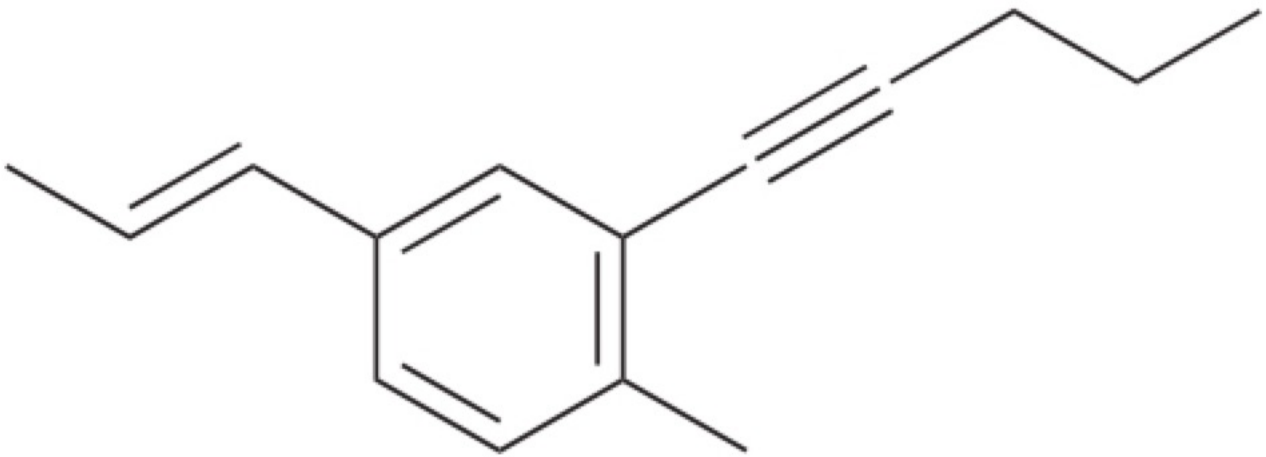
iClicker Question

What was the most challenging part of what we learned so far?

A. Lewis structures
B. VSERPR theory
C. Intermolecular forces
D. Phases of matter
E. Polymers

Clicker Question

Identify the number of carbon atoms in this molecule:



A) 12

B) 13

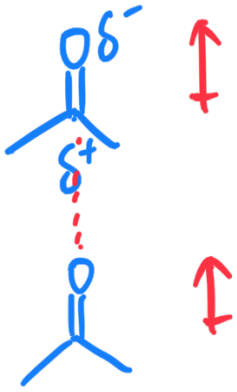
C) 14

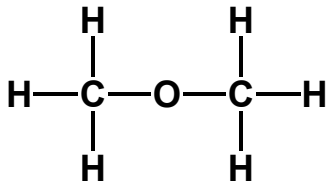
D) 15

E) 16

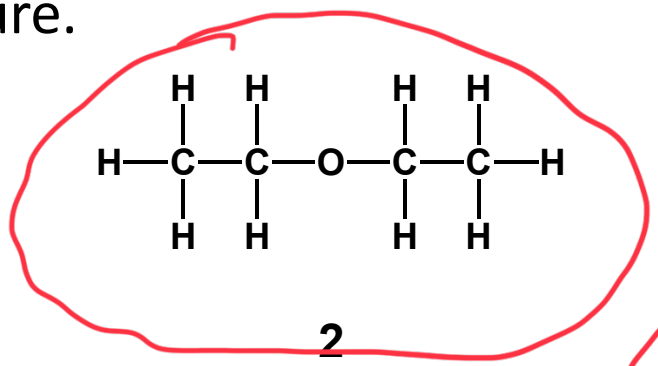
Clicker Question

Arrange the following molecules in order of increasing vapour pressure at room temperature.

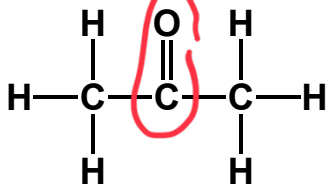




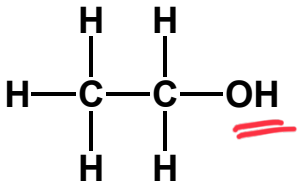
1



2



3



4

a) 2 < 3 < 1 < 4

b) 1 < 4 < 3 < 2

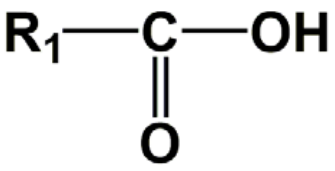
c) 4 < 3 < 2 < 1

d) 3 < 4 < 1 < 2

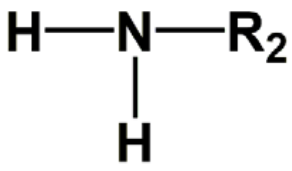
e) 4 < 1 < 2 < 3

Functional groups

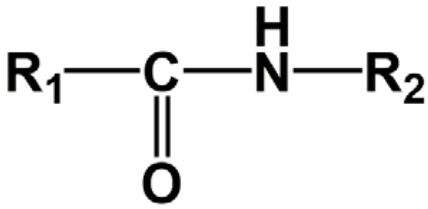
- Moieties in a molecule that have characteristic properties such as reactivity.
- An “R” substituent denotes a part of a molecule that is not relevant to the reactivity being discussed.



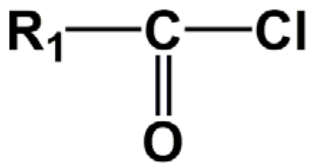
Carboxylic Acid



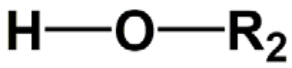
Amine



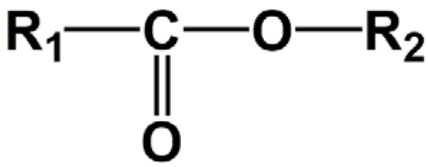
Amide



Acid chloride



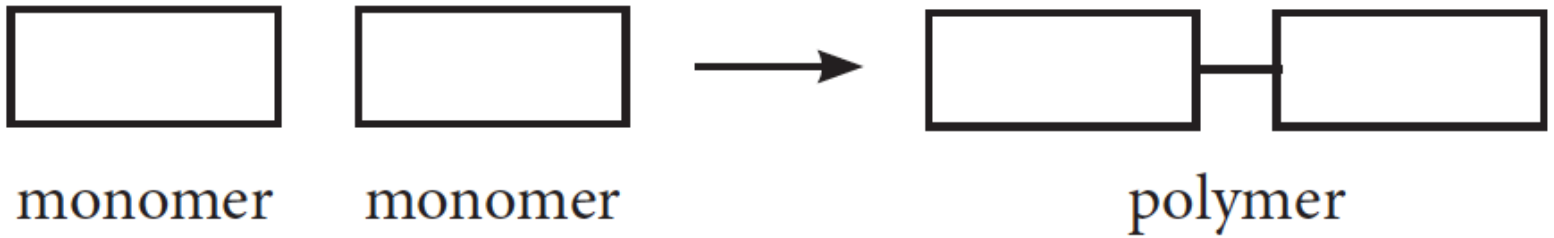
Alcohol



Ester

Polymers

A polymer is a macromolecule constructed by a sequential stringing together of smaller molecules called monomers.



We'll discuss two types of polymers:

- Condensation polymers
- Addition polymers

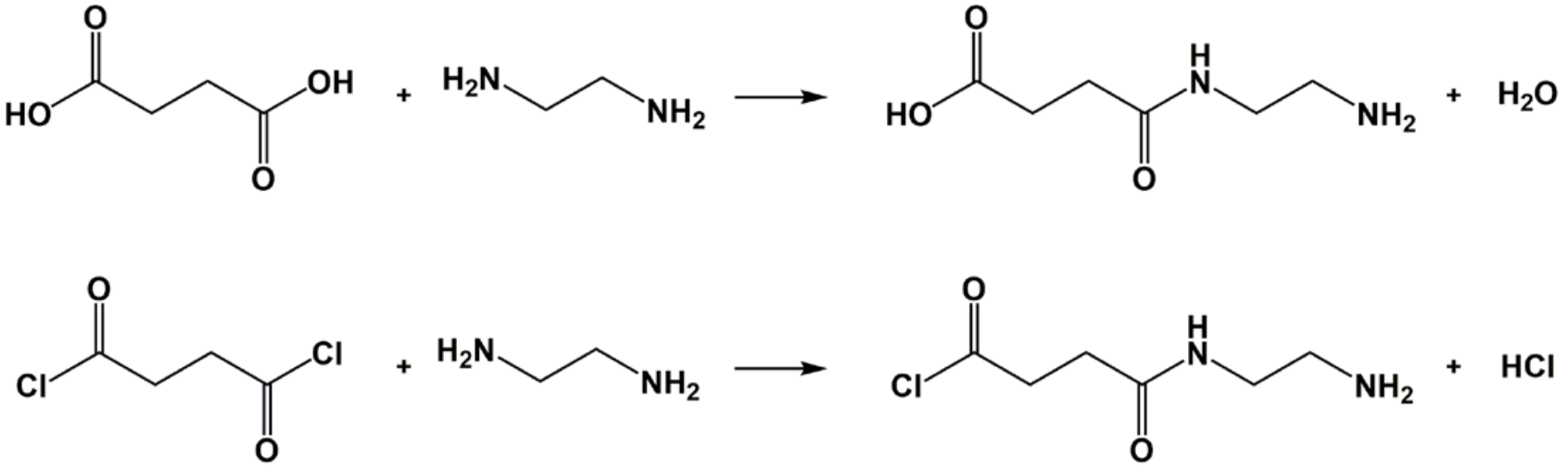
Degree of polymerization

The degree of polymerization (DP) is the number of repeat units in a polymer chain. For example:

Structure	DP
Dimer	2
Trimer	3
Tetramer	4
Pentamer	5
Oligomer	Small
Polymer	Large

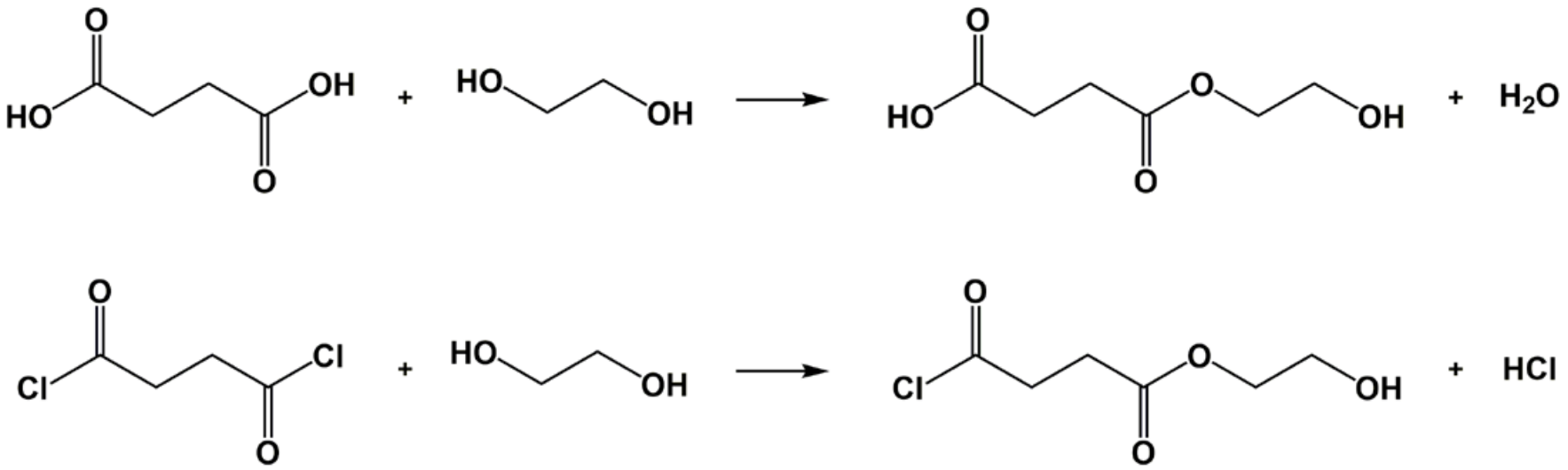
Condensation Polymers – Amide linkage

- Two monomers join together to form a polymer and a small molecule byproduct (water or hydrochloric acid).
- Condensation monomers have two reactive sites.
- An amide linkage is formed when carboxylic acids OR an acid chloride react with amines.
- The amide linkage repeats along backbone of polymer.



Condensation Polymers – Ester linkage

- An ester linkage is formed when carboxylic acid OR an acid chloride reacts with alcohols.
- The ester linkage repeats along the backbone of the polymer.

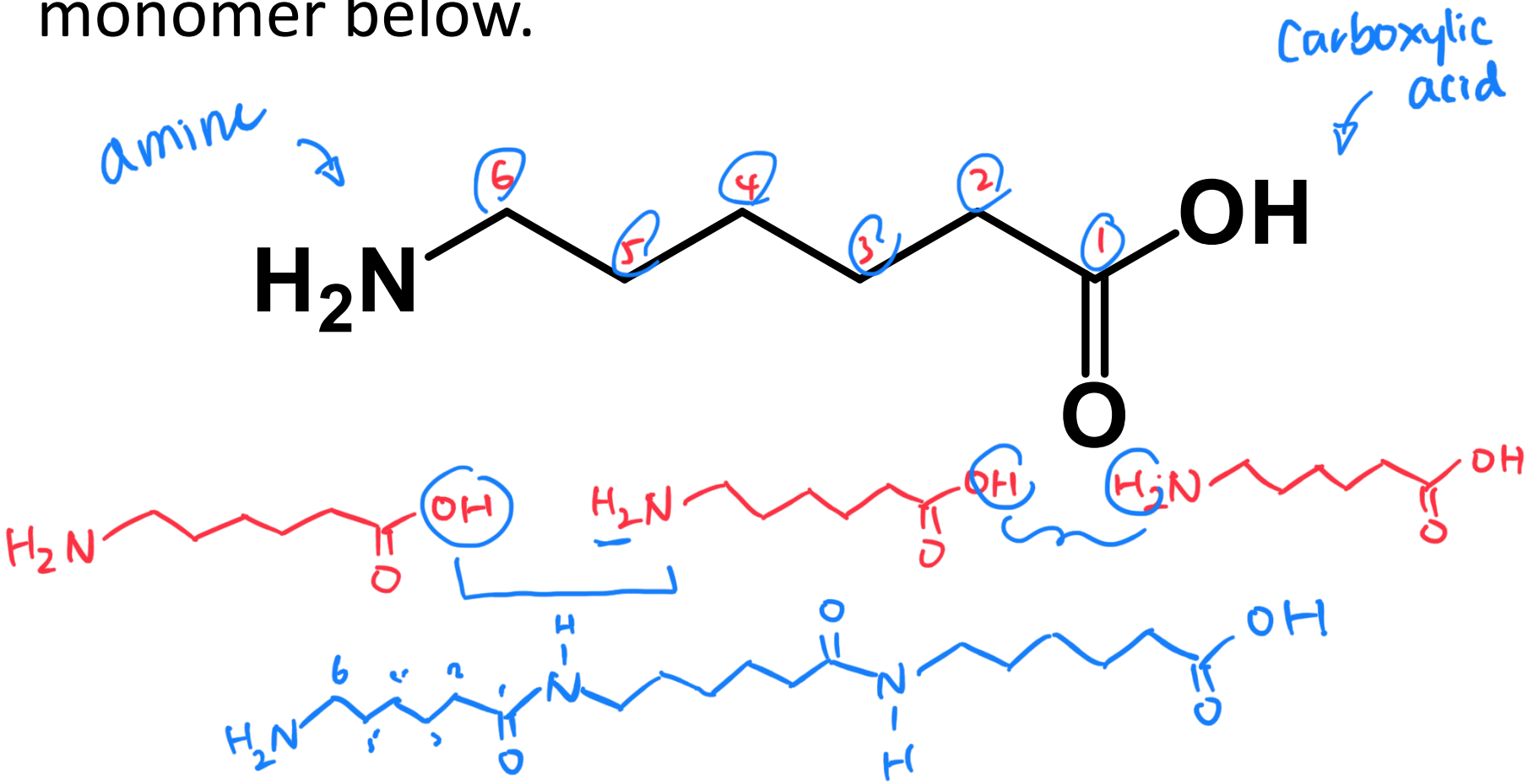


Summary of condensation polymer reactivity

Reactant 1	Reactant 2	Polymer linkage	Small molecule
Carboxylic acid	Amine	Amide	Water
Acid chloride	Amine	Amide	HCl
Carboxylic acid	Alcohol	Ester	Water
Acid chloride	Alcohol	Ester	HCl

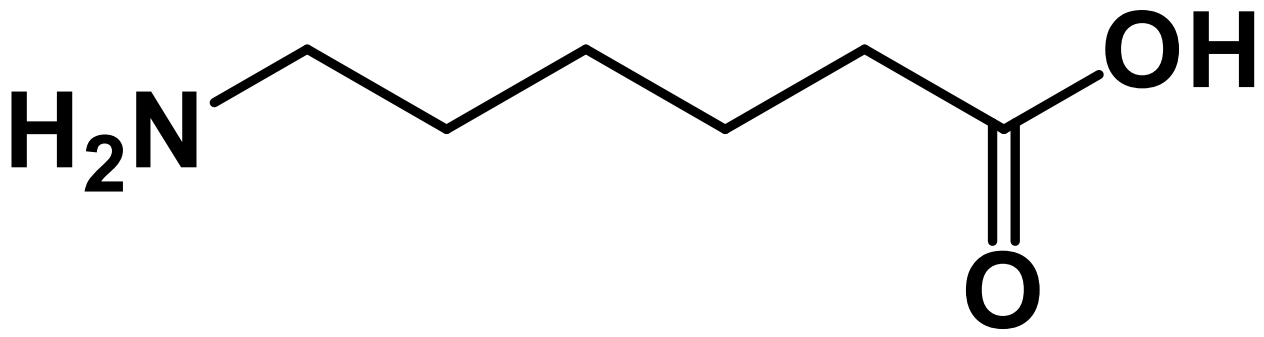
Worksheet Question #3

Draw the structure of the **trimer** and of a polymer resulting from the condensation of the monomer below.



Worksheet Question #3 (Clicker)

Draw the structure of the **trimer** and of a polymer resulting from the condensation of the monomer below. Name the linkage.



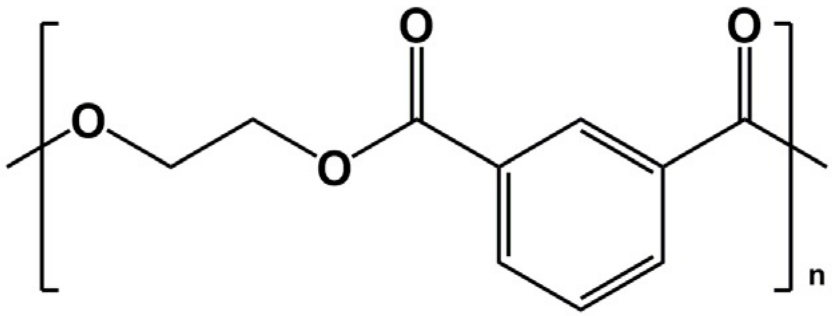
What kind of linkage will be formed?

a) Ester

b) Amide

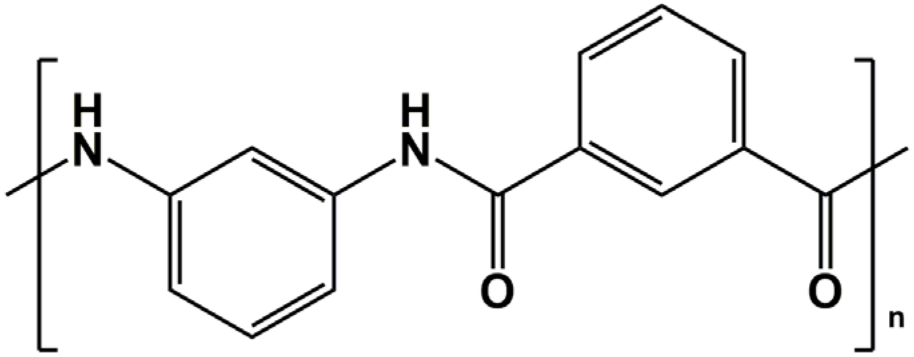
Worksheet Question #4(a)

Draw the structure of the smallest possible monomer(s) that corresponds to the polymers. Name the type of linkage in the backbone of the polymer…



Worksheet Question #4(b)

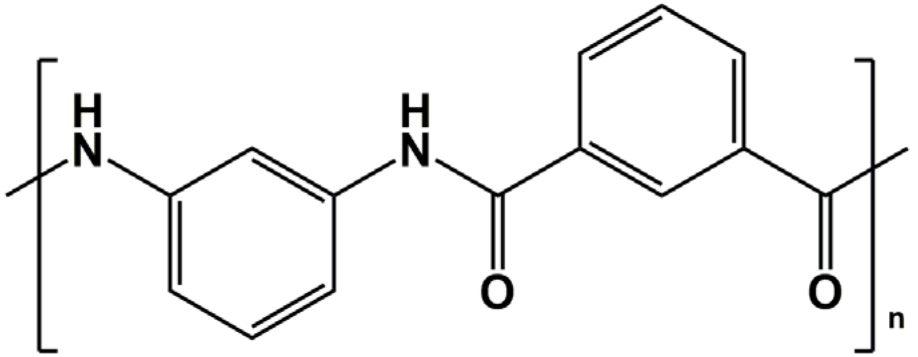
Draw the structure of the smallest possible monomer(s) that corresponds to the polymers. Name the type of linkage in the backbone of the polymer…



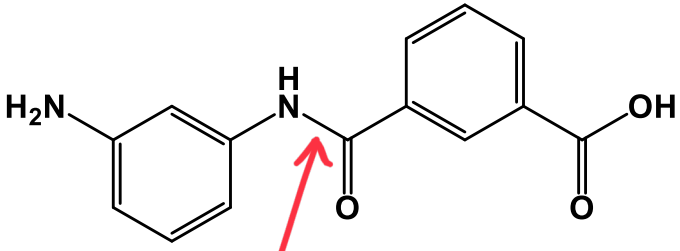
This polymer is Nomex (fire resistant fabric)

Clicker Question - Worksheet Question #4b

What is the structure of the MONOMER(S) for the polymer at right?

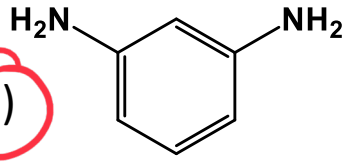


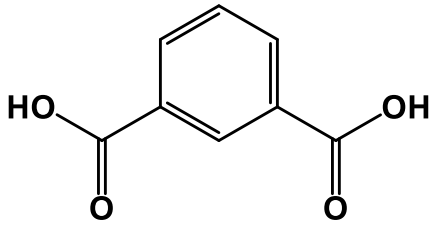
A)



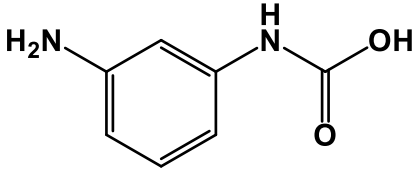
Need to break this linkage

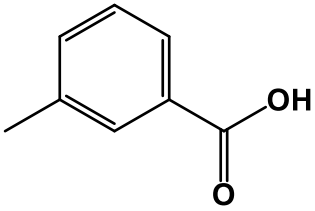
B)



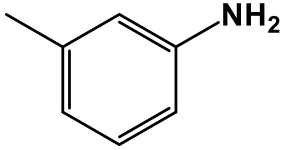


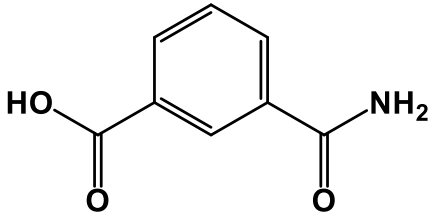
C)





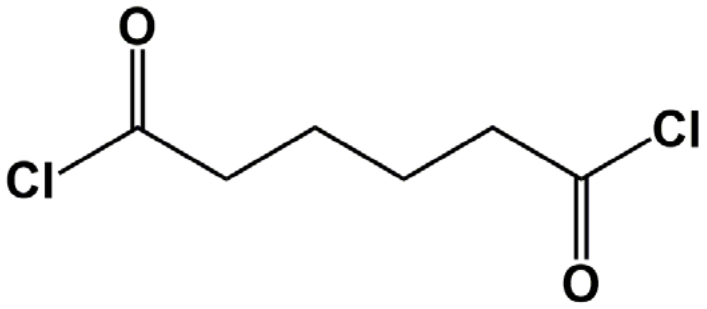
D)



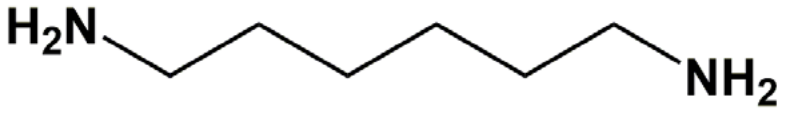


Worksheet Question #5 – GOOD QUESTION

Nylon is a polymer that can be prepared by the reaction of sebacoyl chloride and 1,6-diaminohexane.



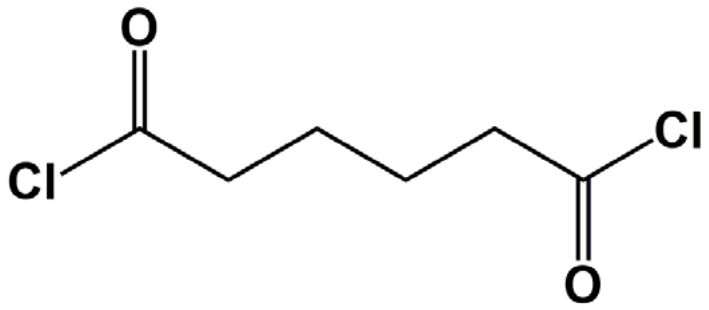
Sebacoyl chloride



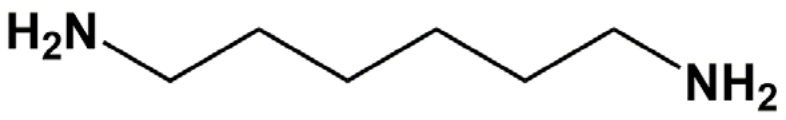
1,6-diaminohexane

Worksheet Question #5 – GOOD QUESTION

(a) A mixture of sebacoyl chloride in water and 1,6-diaminohexane in hexanes forms a biphasic mixture (a mixture with two layers). Provide possible reasons for this explanation.



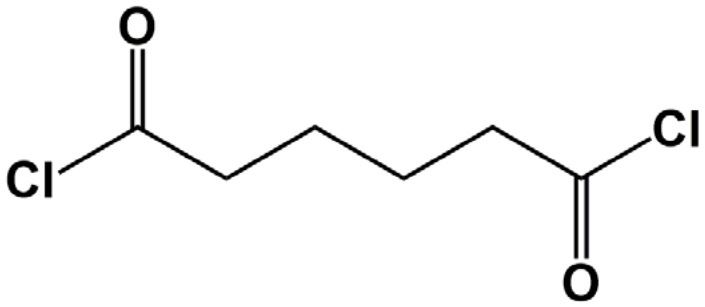
Sebacoyl chloride



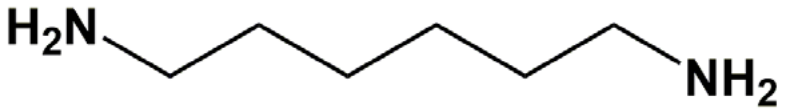
1,6-diaminohexane

Worksheet Question #5 – GOOD QUESTION

(b) Draw the product(s) of the reaction between sebacoyl chloride and 1,6-diaminohexane. Where does the reaction take place? Explain.



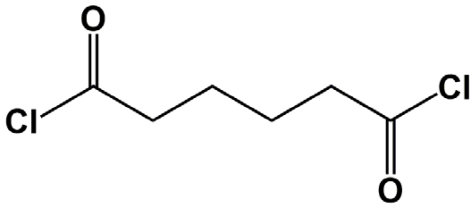
Sebacoyl chloride



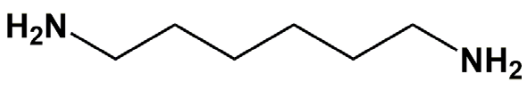
1,6-diaminohexane

Worksheet Question #5 – GOOD QUESTION

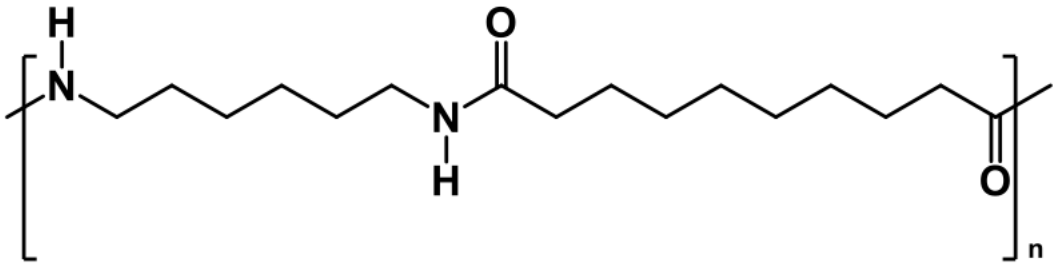
(b) Draw the product(s) of the reaction between sebacoyl chloride and 1,6-diaminohexane…
Where does the reaction take place? Explain.



Sebacoyl chloride



1,6-diaminohexane



+

HCl

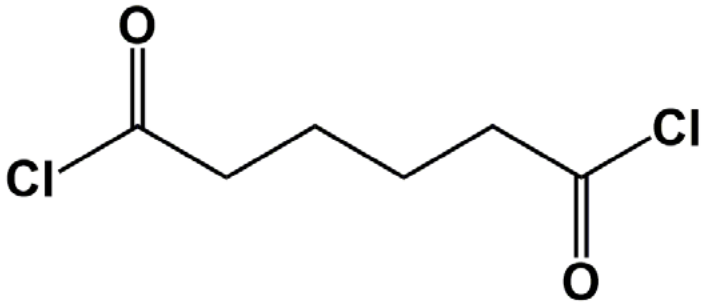
Worksheet Question #5 – GOOD QUESTION

(b) Draw the product(s) of the reaction between sebacoyl chloride and 1,6-diaminohexane. Where does the reaction take place? Explain.

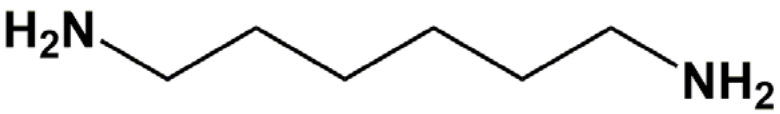
a) Bottom layer

b) Top layer

c) At the interface



Sebacoyl chloride

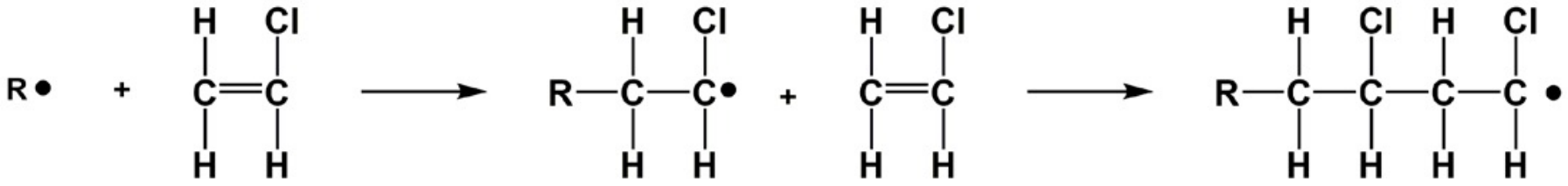


1,6-diaminohexane

Addition Polymers

Addition reactions occur when two or more molecules join to form a larger molecule *without* the loss of any atoms / small molecules.

R• is an abbreviation for a molecule that initiates the polymerization process.



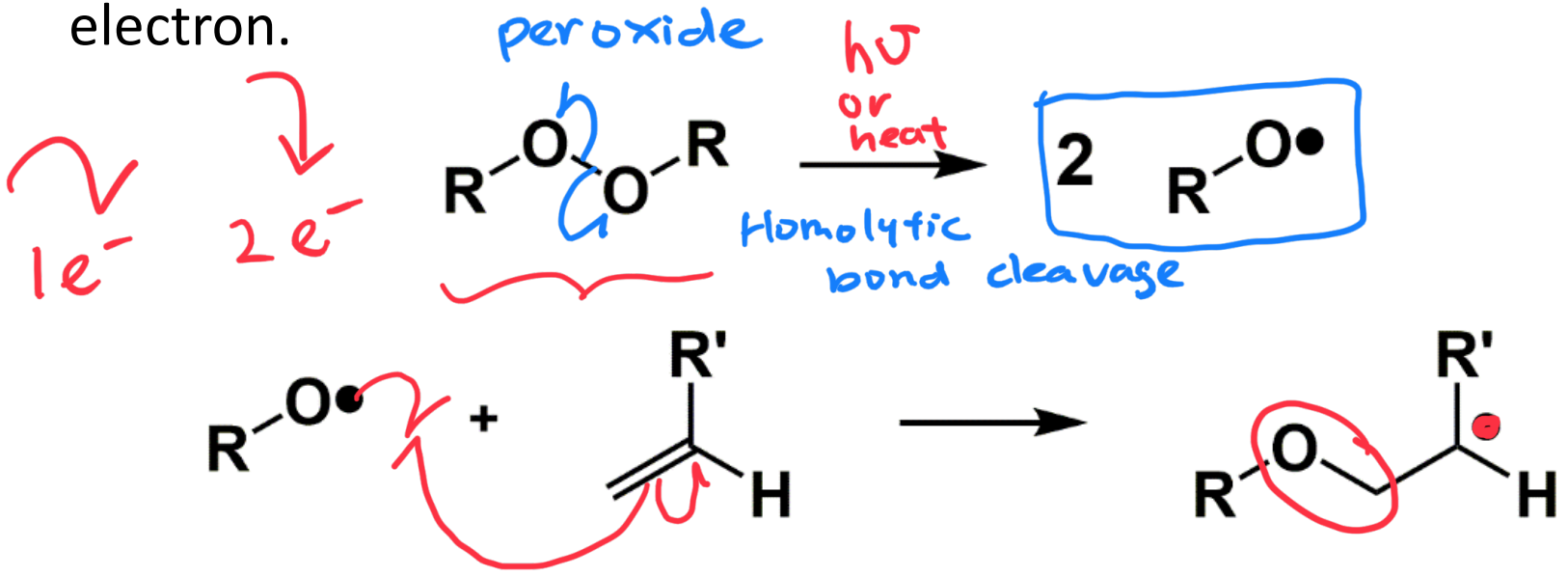
Polymerization steps

Addition polymerization occurs in three key stages:

1) **Initiation.** Number of radicals increases.
2) **Propagation.** Number of radicals remains constant.
3) **Termination.** Number of radicals decreases.

Initiation

A polymerization reaction starts by the formation of a reactive species such as a free radical. Radicals are very reactive species with an odd number of electrons. Radicals are generally abbreviated as R·, where the dot represents the unpaired electron.

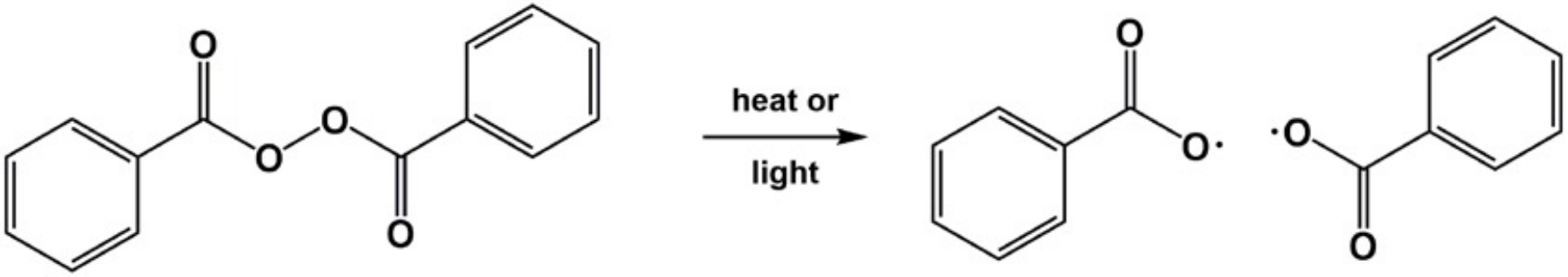


In general: RO· Is just notated as R·

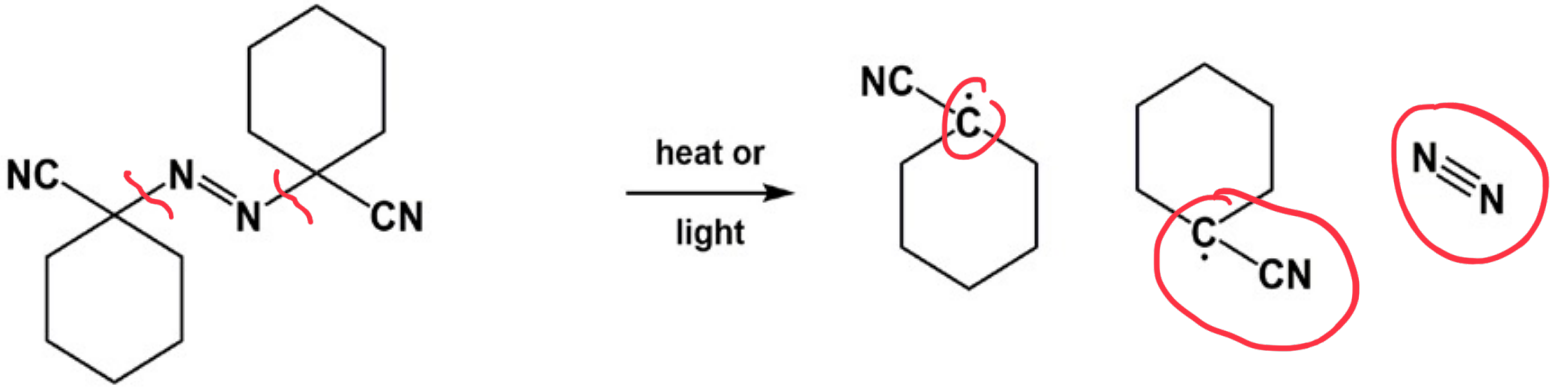
Initiators

A common radical initiator. Peroxides may be explosive.

Benzoyl peroxide:



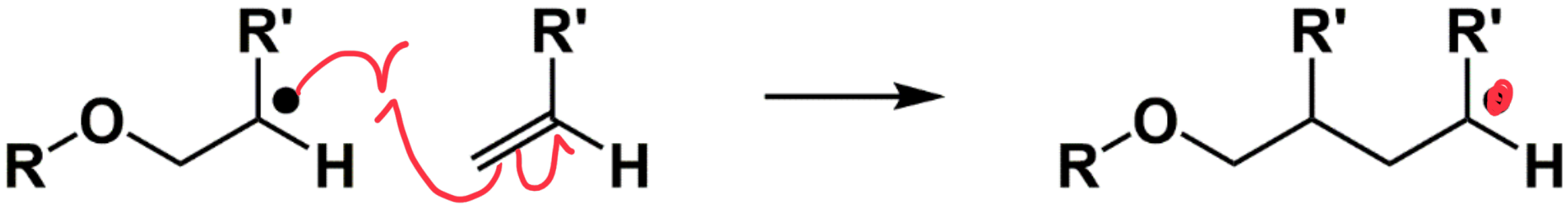
Azobisisobutyronitrile (AIBN):



You do NOT need to memorize these structures

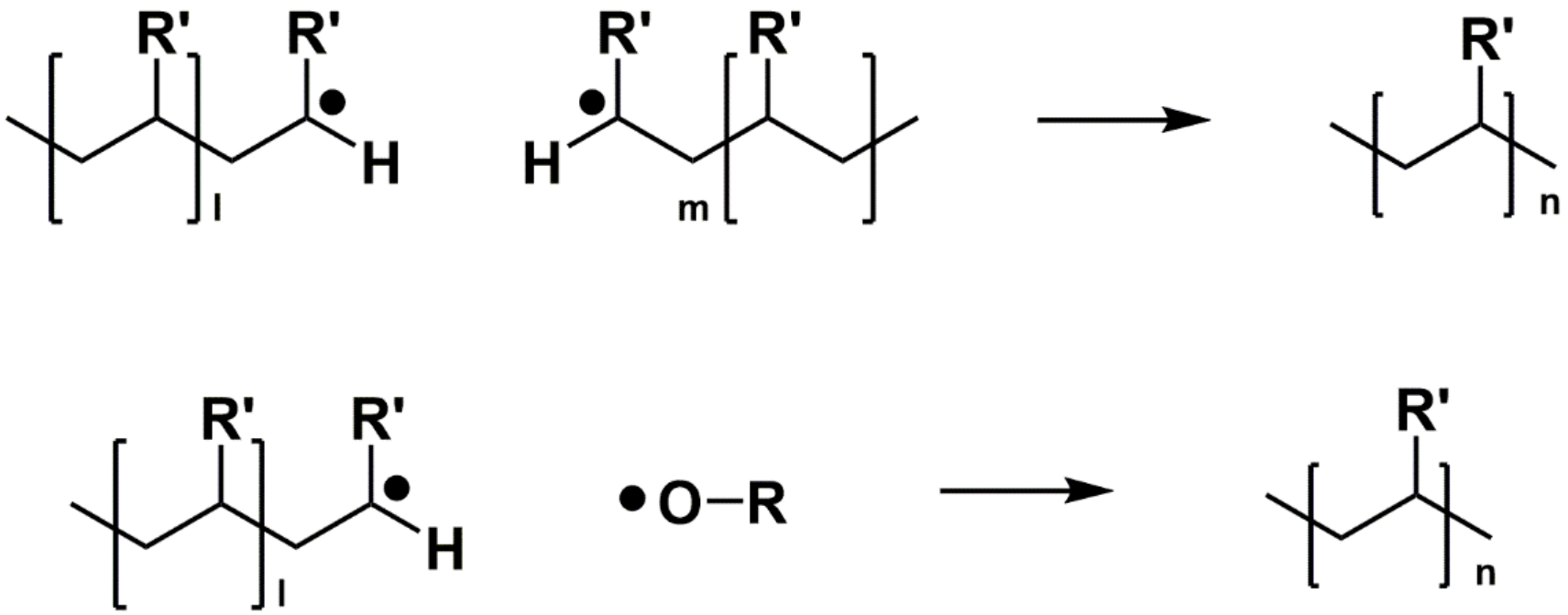
Propagation

A growing polymer chain reacts with a monomeric unit, extending the length of the polymer. No overall change in number of radical species.

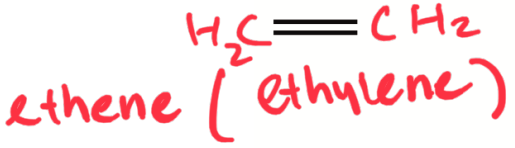


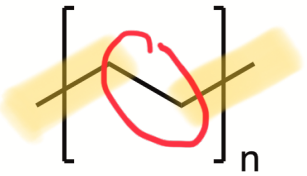
Termination

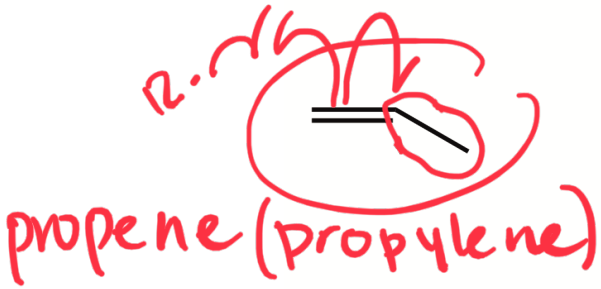
Reaction between a growing chain and another radical species (another growing chain, or an initiator).

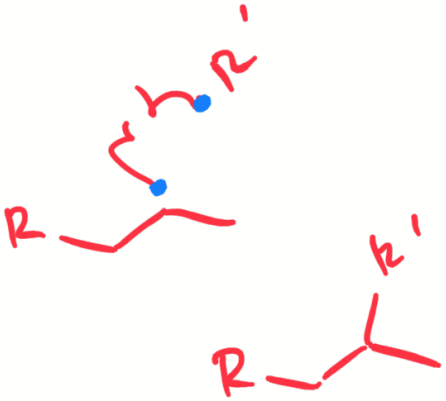


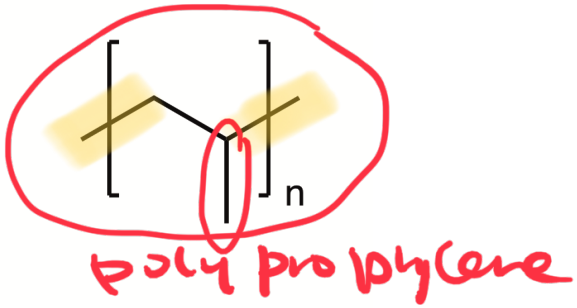
Examples of addition polymers

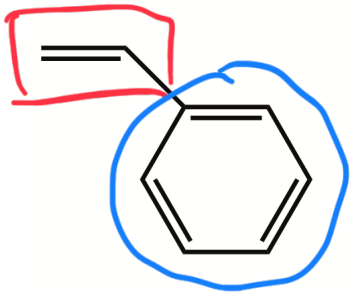


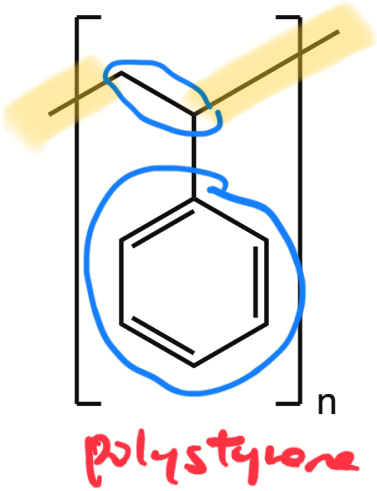












Examples of addition polymers