Welcome to Chemistry 154!

Chemistry for Engineering

Reminders

- **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**

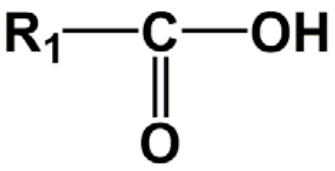
Videos 1 and 2: summarizes the main content of Unit 5

Videos 3-10: interactive videos on polymers

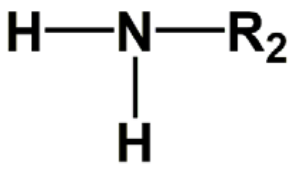
Instructor Office Hours
Monday and Friday 7-8pm via Zoom (All Lectures Site)

Functional groups

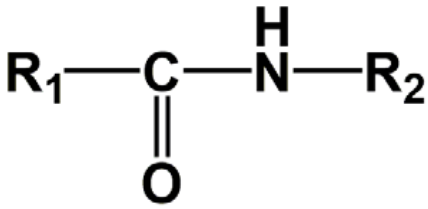
- Moieties in a molecule that have characteristic properties such as reactivity.
- An “R” substituent denotes a part of a molecule that is not relevant to the reactivity being discussed.



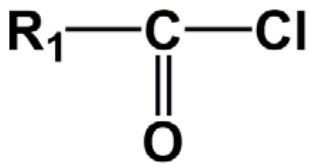
Carboxylic Acid



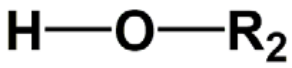
Amine



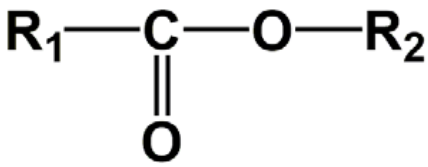
Amide



Acid chloride



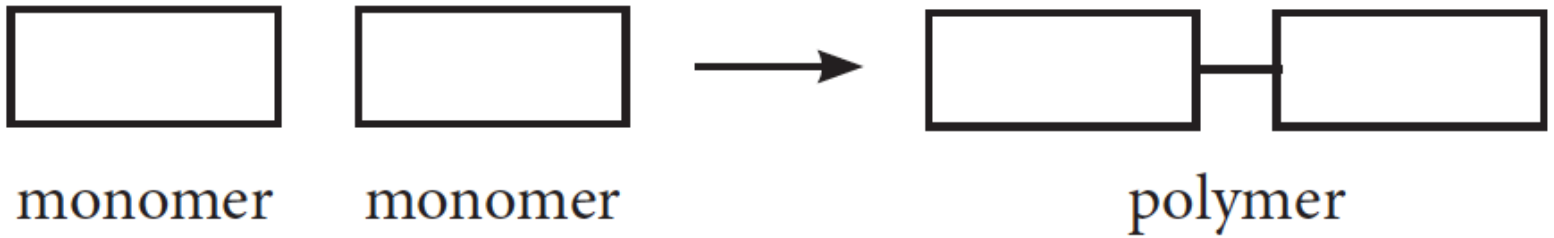
Alcohol



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

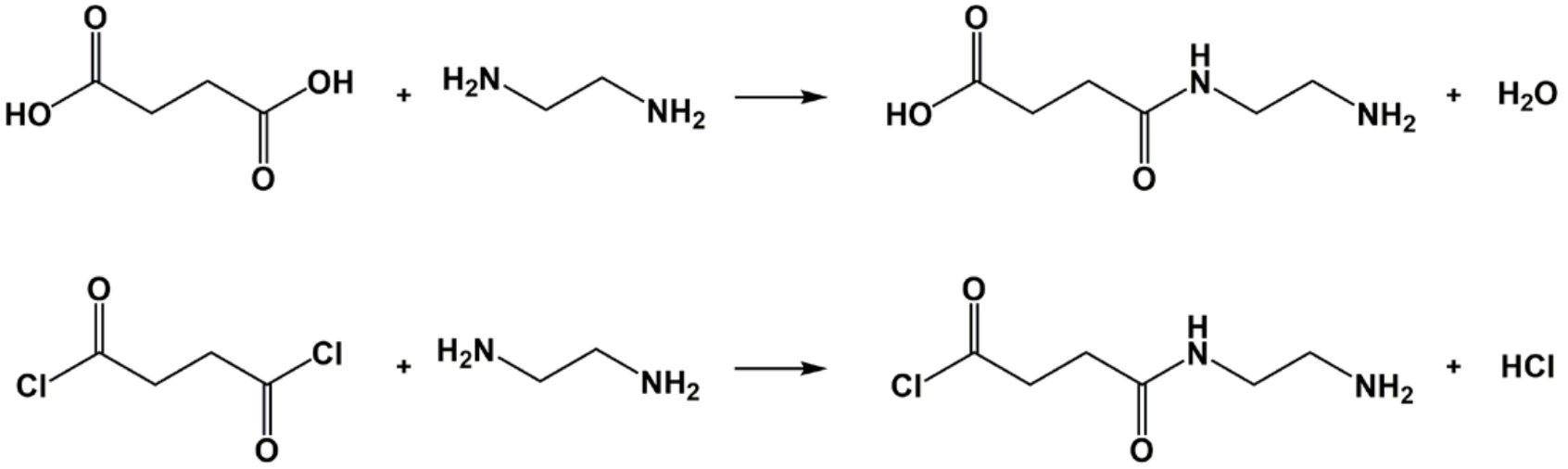
Degree of polymerization

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

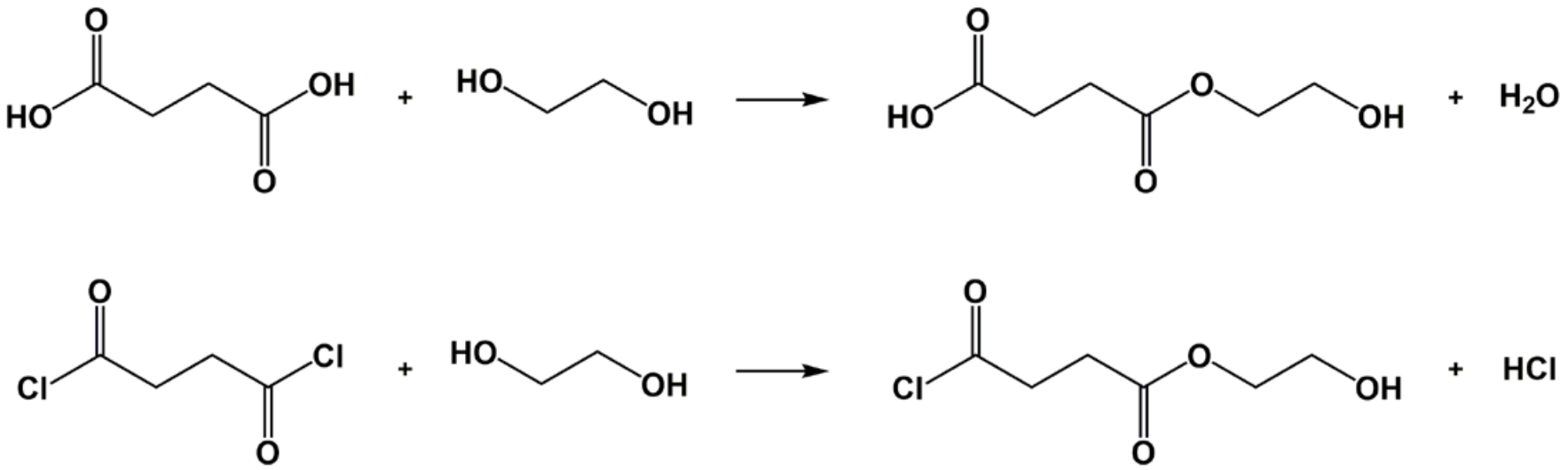
Condensation Polymers – Amide linkage

- 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

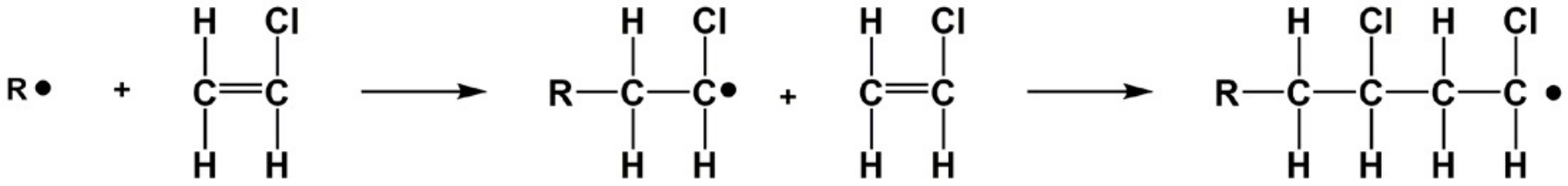
- An ester linkage is formed when carboxylic acid OR an acid chloride reacts with alcohols.
- The ester linkage repeats along the backbone of the polymer.



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.



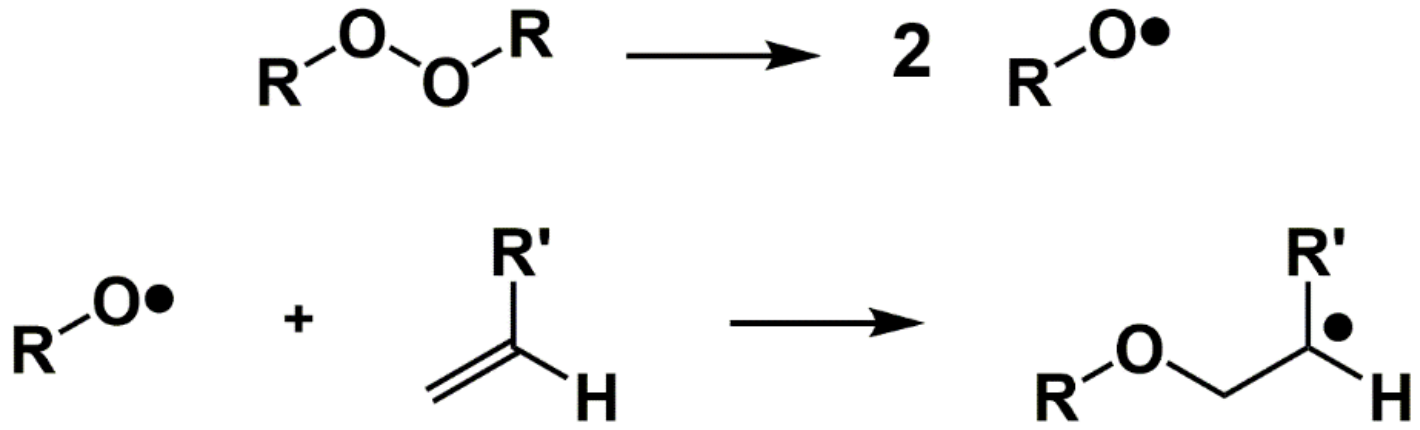
Polymerization steps

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.

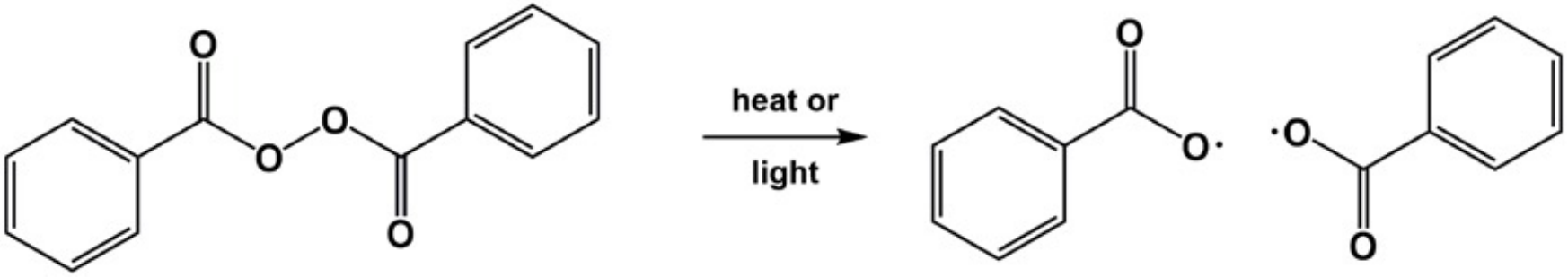


In general: RO· Is just notated as R·

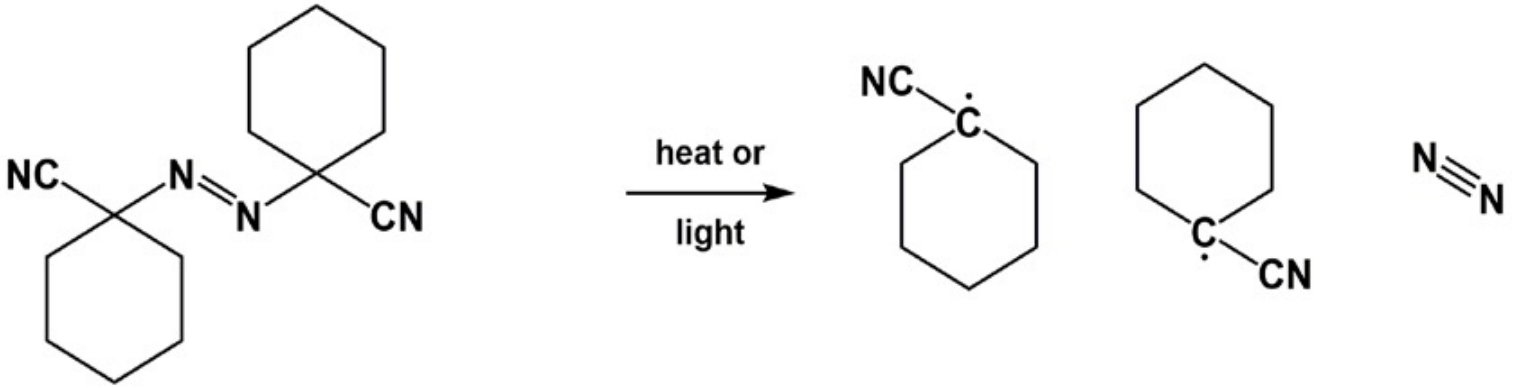
Initiators

A common radical initiator. Peroxides may be explosive.

Benzoyl peroxide:



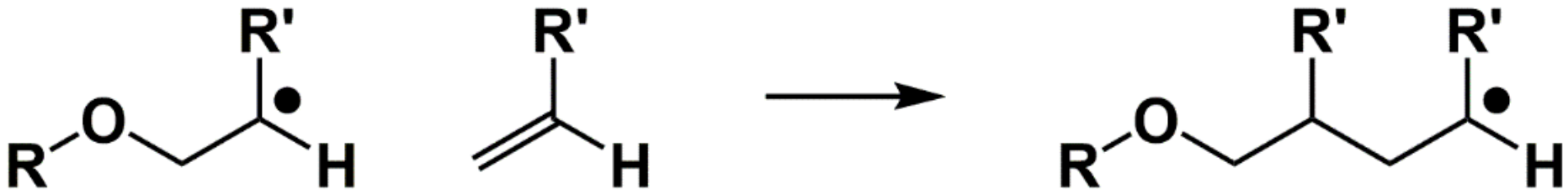
Azobisisobutyronitrile (AIBN):



You do NOT need to memorize these structures

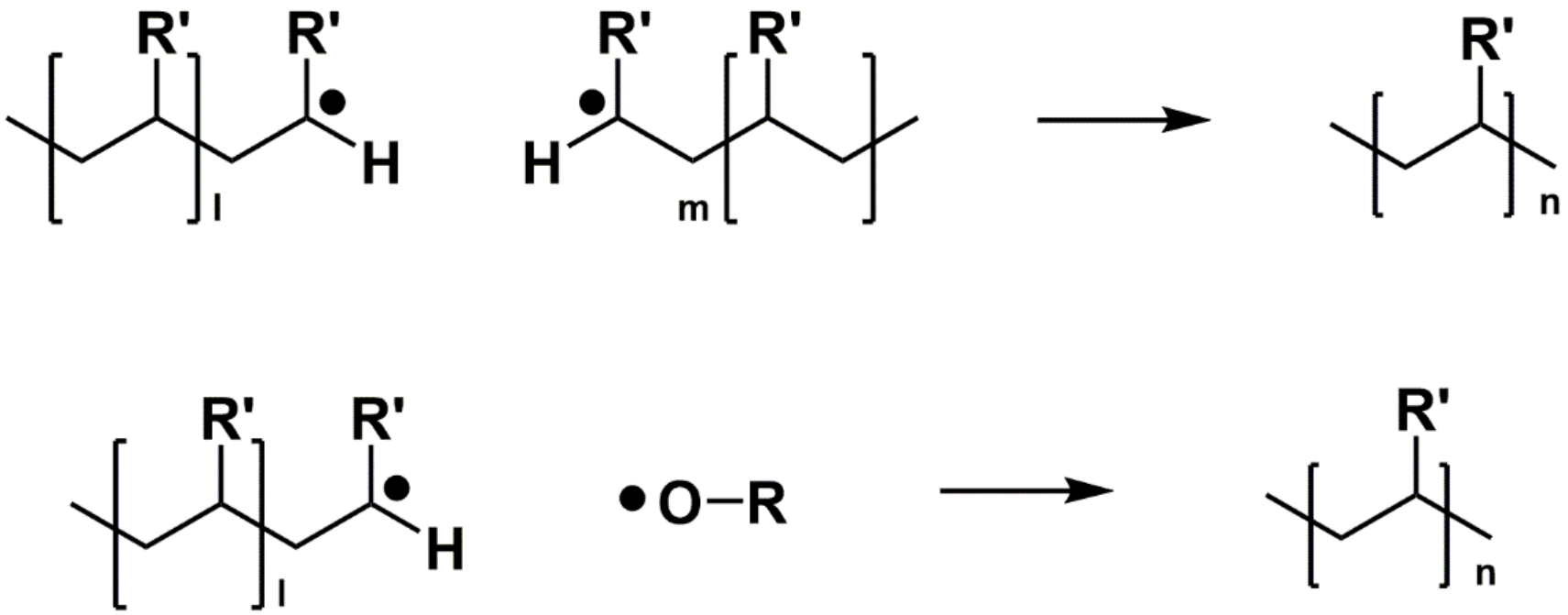
Propagation

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

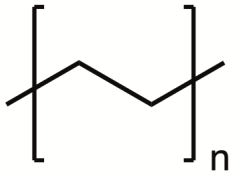


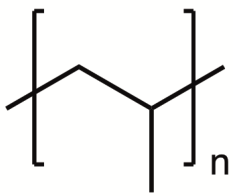
Termination

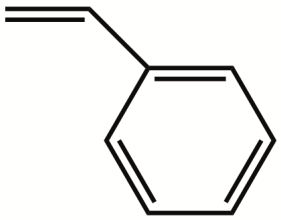
Reaction between a growing chain and another radical species (another growing chain, or an initiator).

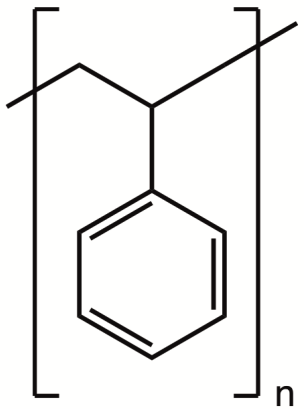


Examples of addition polymers

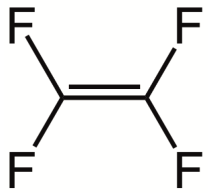


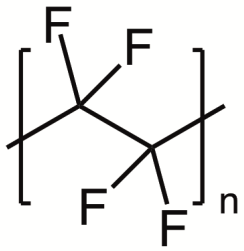


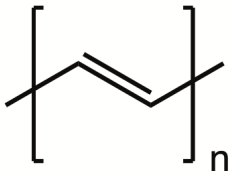




Examples of addition polymers

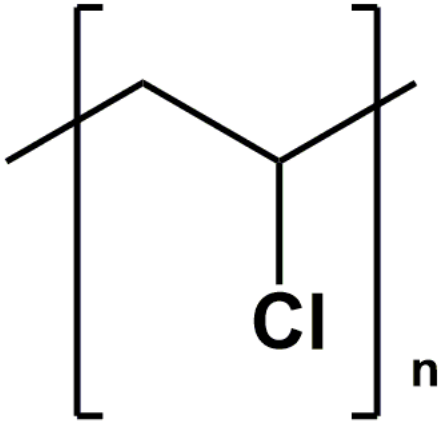






Worksheet Question #7(a)

Draw the structure of the smallest possible monomer(s) that corresponds to these polymers…



Click in:

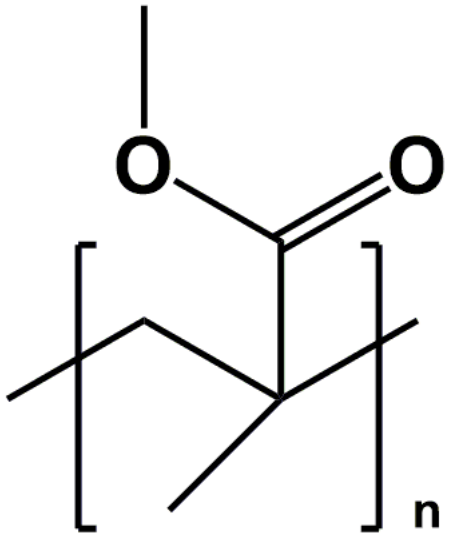
A. I'm done!

B. I'm stuck... ☹

C. I'm still working

Worksheet Question #7(b)

Draw the structure of the smallest possible monomer(s) that corresponds to these polymers…



Click in:

A. I'm done!

B. I'm stuck... ☹

C. I'm still working

Inclass Practice: SF_4. (5 points in total)

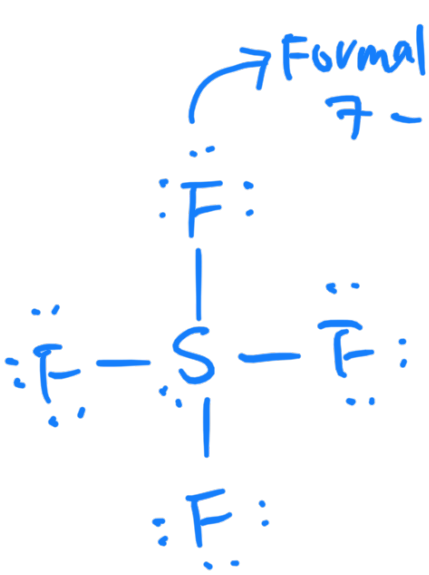
1) draw the best Lewis structure

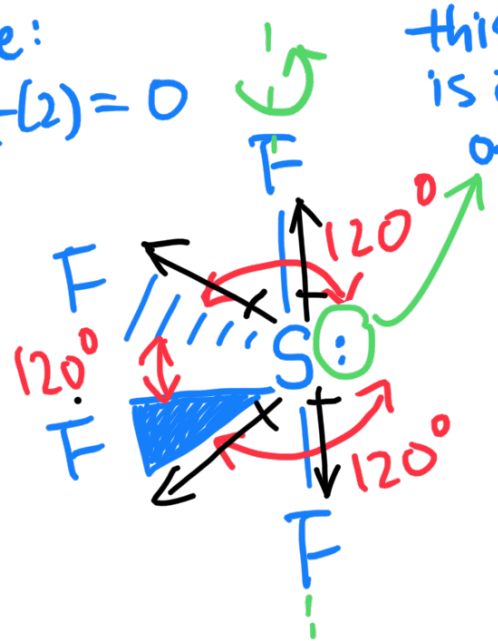
2) draw the perspective diagram

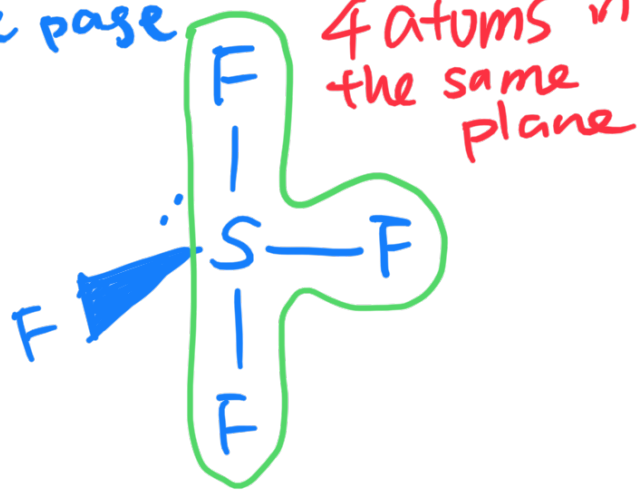
3) What is the molecular shape? Seesaw

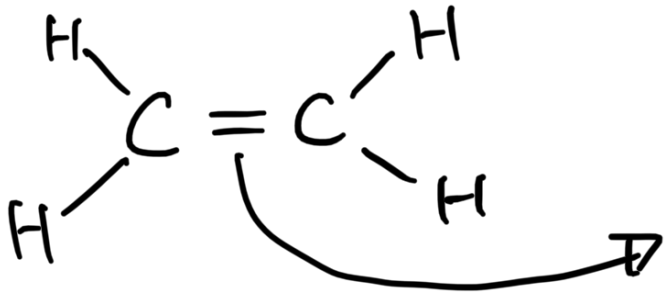
4) maximum number of atoms in the same plane? → 4

5) polarity? Polar



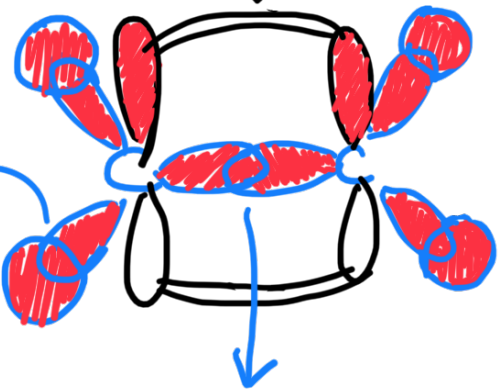






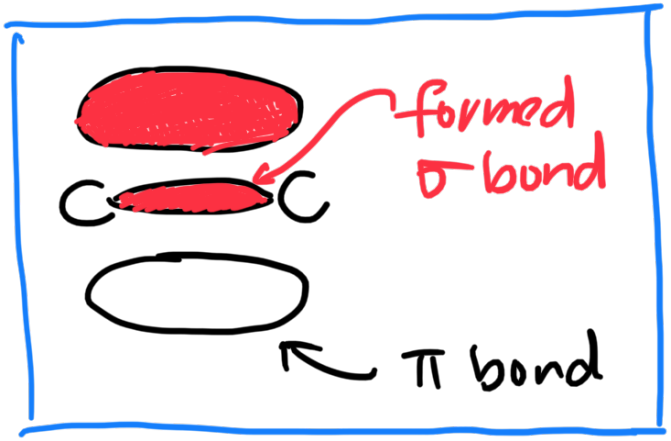
double bond = σ bond + π bond

this overlap forms π bond, which looks like



σ bond between carbon atoms

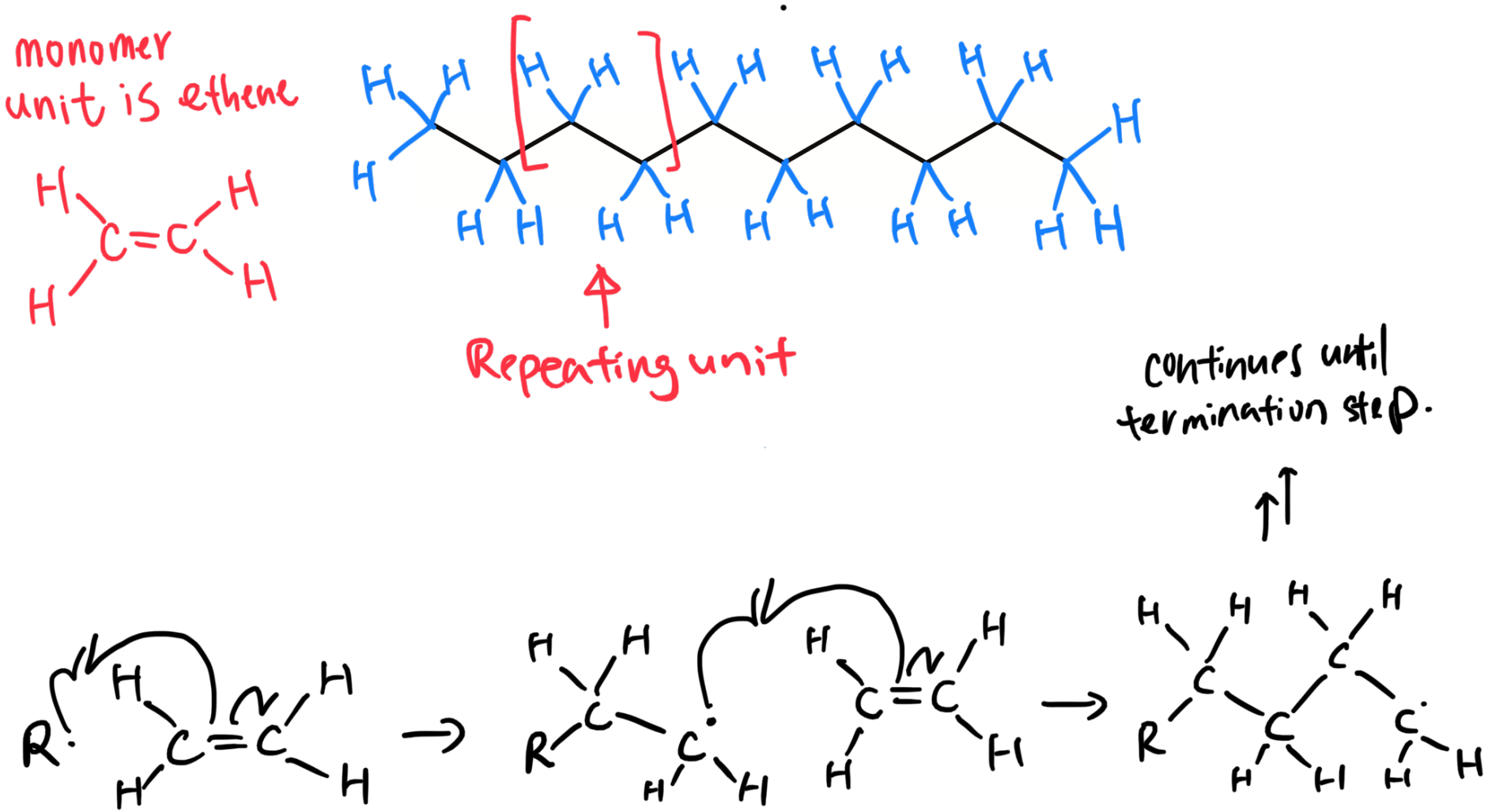
σ bond (Carbon – Hydrogen)



C=C double bond

Worked example

Draw the chemical structures of the monomer(s) that correspond to the following polymers.



Worked example

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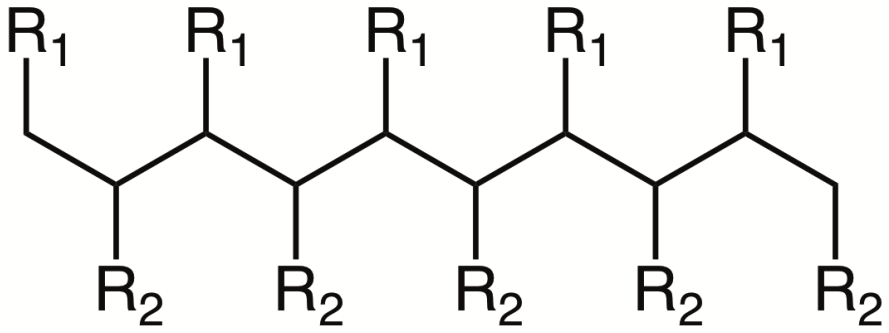
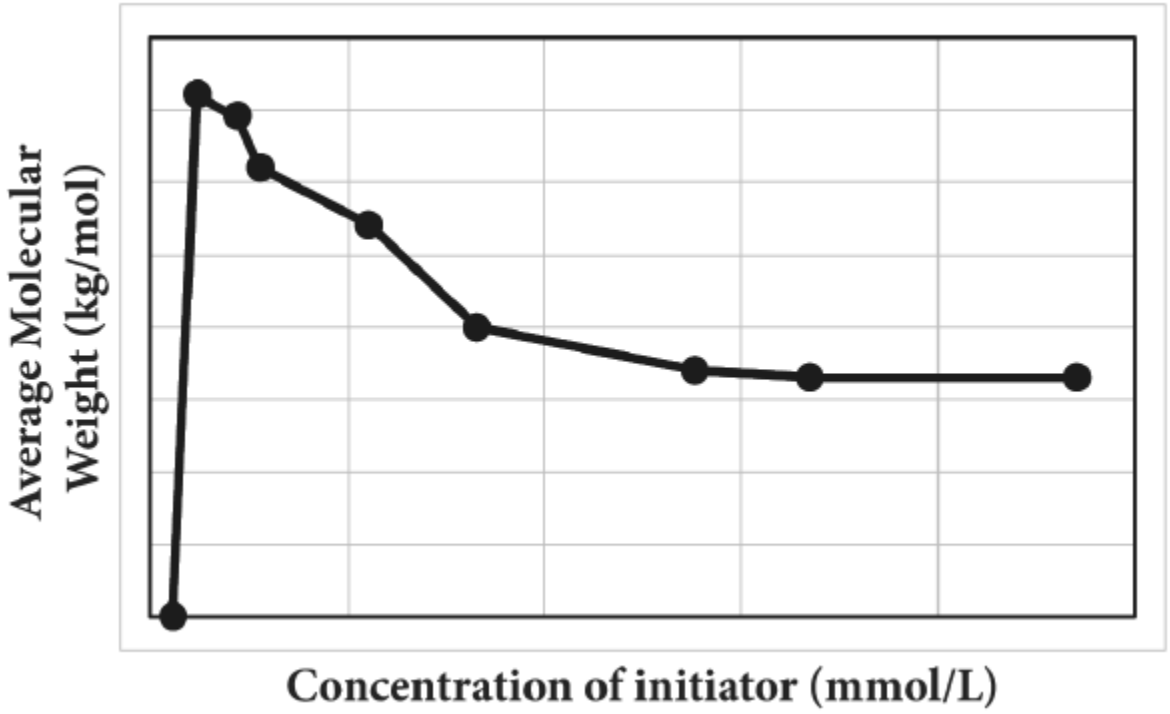


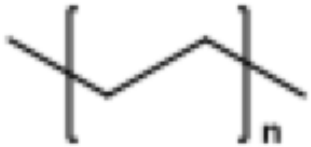
Worksheet Question #8 – GOOD QUESTION

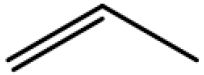
Provide a valid explanation for the trend in polymer molecular weight of poly(methyl methacrylate) shown below.



Review Clicker Question

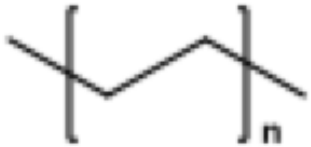
What is the structure of the MONOMER(S) for the polymer at right?

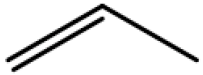


				I have no idea
A.	B.	C.	D.	E.

Review Clicker Question

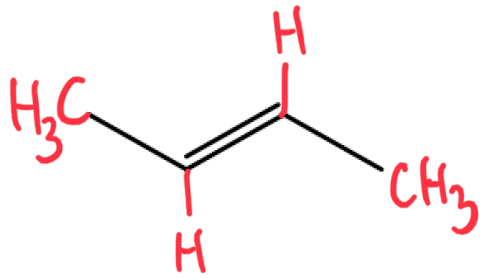
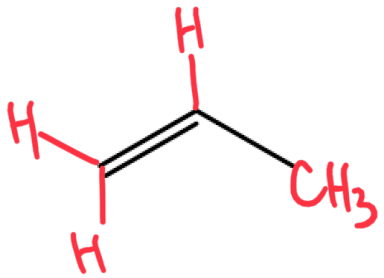
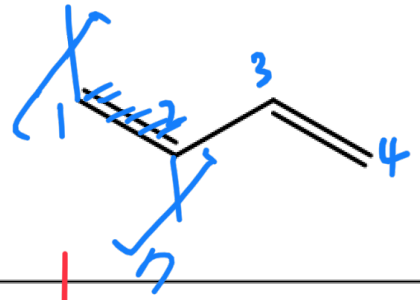
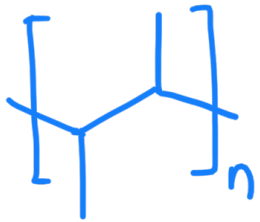
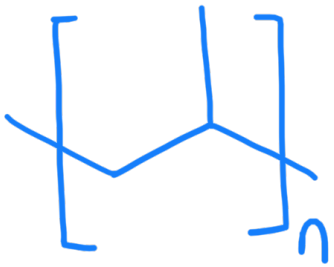
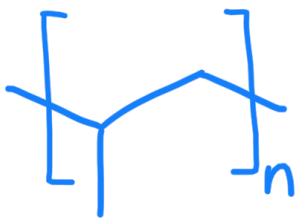
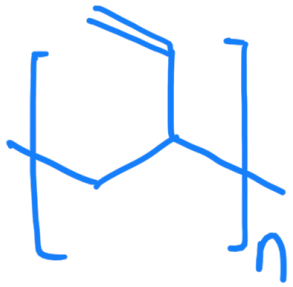
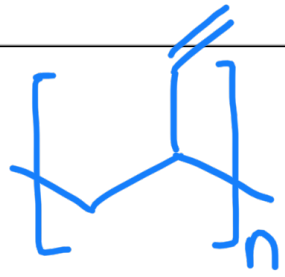
What is the structure of the MONOMER(S) for the polymer at right?



				I have no idea
A.	B.	C.	D.	E.

Draw the resulting polymers for ALL INCORRECT options

Review Clicker Question

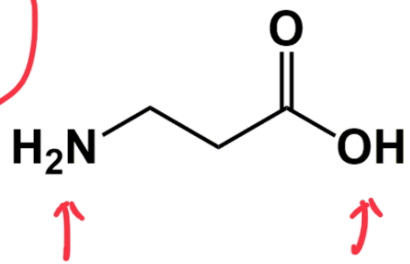
Monomer			
Polymer		 or 	Redraw  or 

Clicker review: worksheet question 9

Which of the monomers below directly lead to condensation polymerization reactions?

bifunctional molecule

A

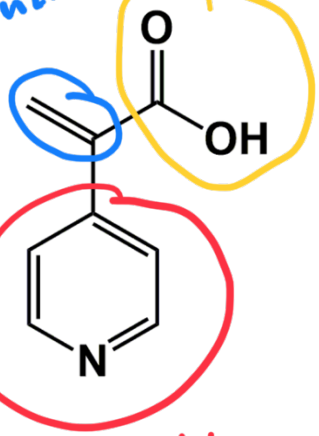


two functional groups

Addition polymerization

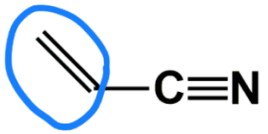
only 1 functional group, cannot be condensation polymerization

B



benzene like rings don't react

C

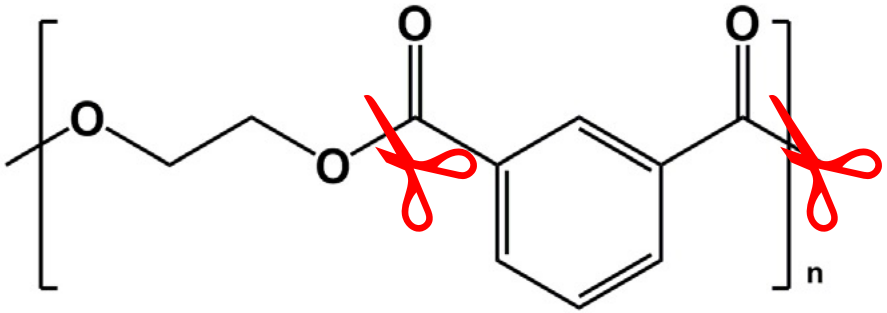


Addition polymerization

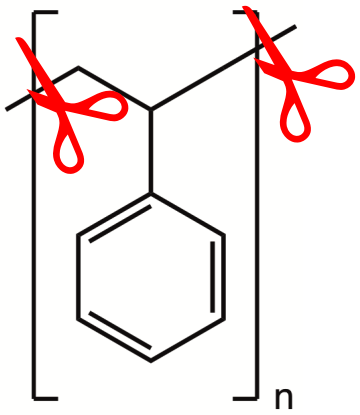
D. Molecules A + B

E. Molecules B + C

Polymer to monomer

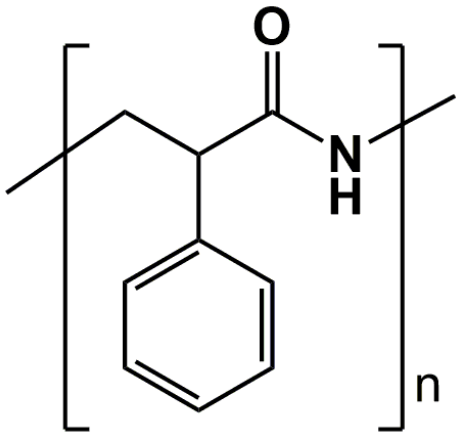


Polymer to monomer



Worksheet Question #9(c)

Fill in the blanks in the table below by drawing the monomer or polymer. Classify each polymer as condensation or addition polymer by circling the correct option. Name the type of linkage.



Worksheet Question #9(c)

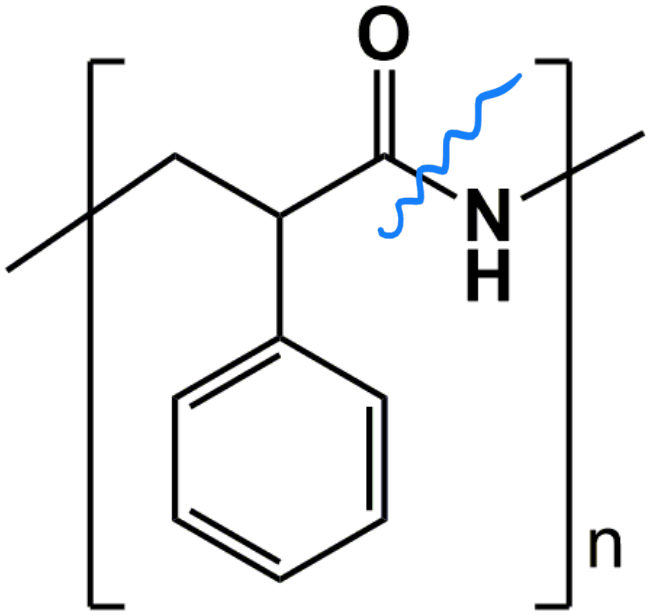
Click in:

A. I'm done!

B. I'm stuck... ☹

C. I'm still working

Worksheet Question #9(c)

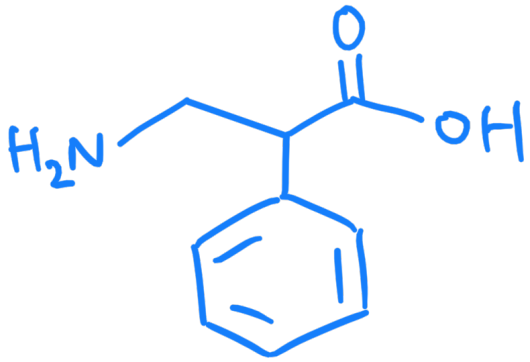


Condensation

What kind of polymerization?

What kind of linkage was formed?

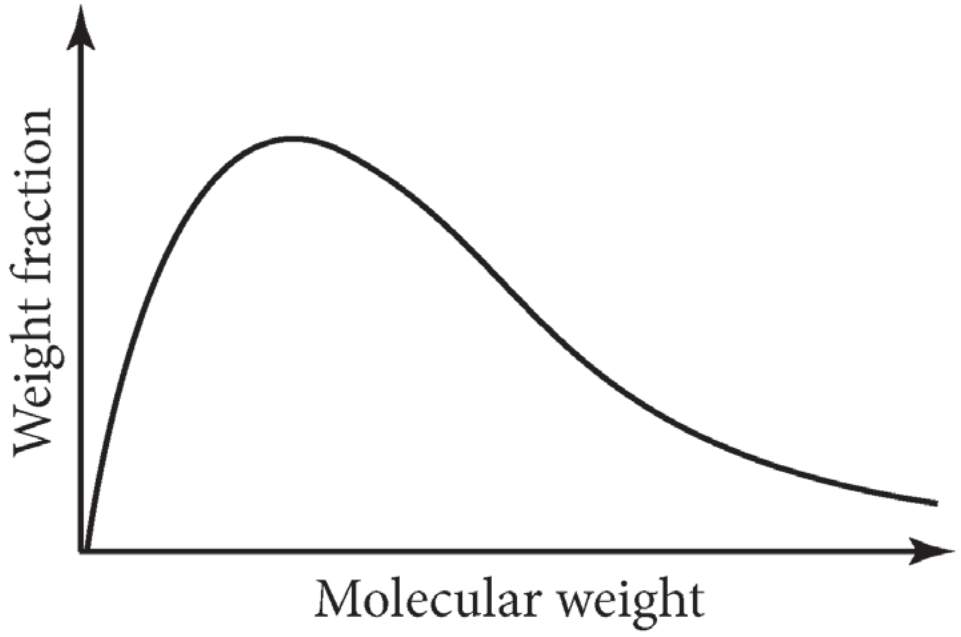
Amide linkage



monomer

Molecular weight distributions

A synthetic polymer will have a range of chain lengths of differing molecular mass, or a *mass distribution*. Differences in molecular weight affect solubility, strength, viscosity, among other properties.

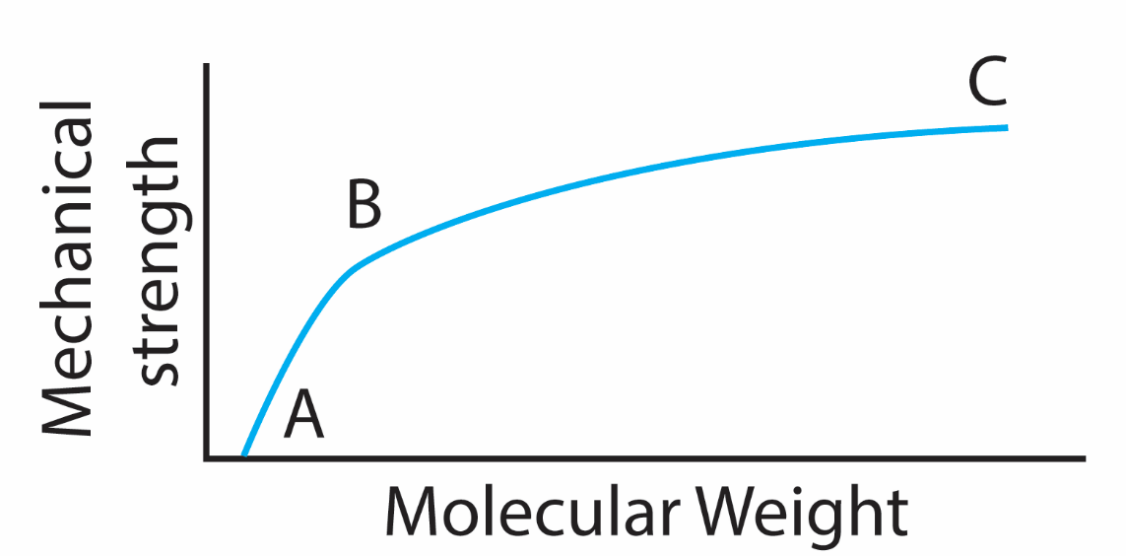


Factors affecting polymer properties

Polymers are versatile materials because their properties can be tailored in a number of ways. For instance, molecular weight, architecture, crosslinking, and composition are some of the factors that can be modified to produce materials with different properties.

Molecular weight and mechanical strength

When MW is below a certain point, the polymer has no mechanical strength. As MW increases beyond that point, mechanical strength increases rapidly (A-B). At a given chain length, the increase in MW does not significantly change the mechanical strength of the material.



Architecture

Polymers are not always linear, they can also be branched. Branched polymers can have several architectures: star, comb or brush to name a few. Architecture can have significant effects on polymer properties. For instance, branching can enhance chain entanglement that leads to increased viscosity. A polymer's viscosity is important for polymer processing.