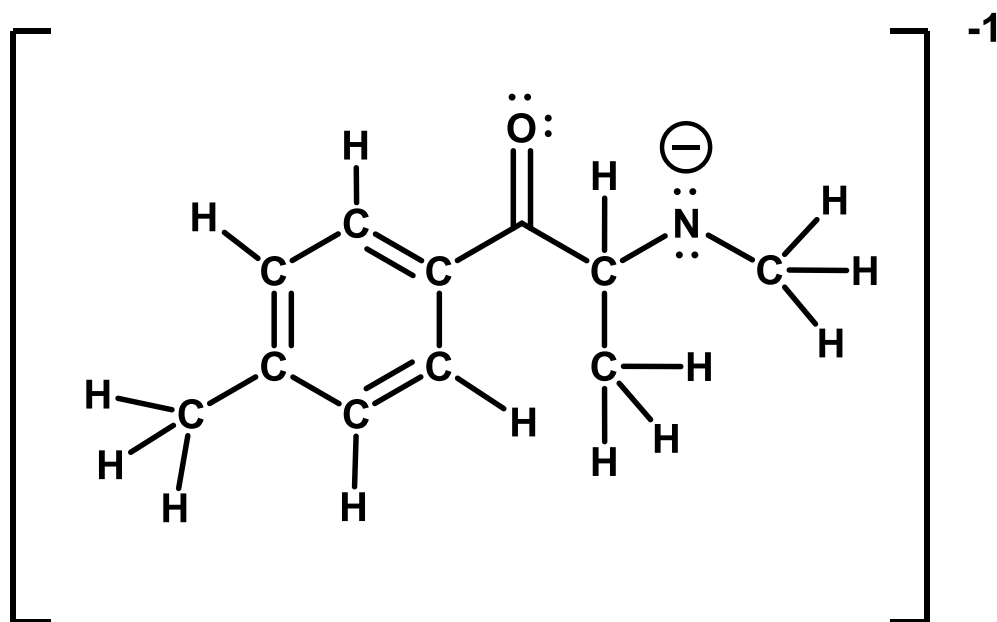
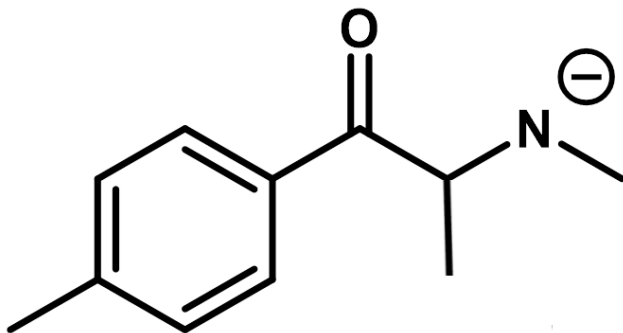
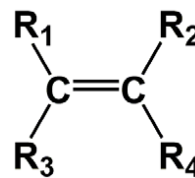


1. Mephedrone is a stimulant that can produce effects similar to those of cocaine. Starting from the shorthand notation of the deprotonated form of mephedrone below, draw its complete Lewis structure.



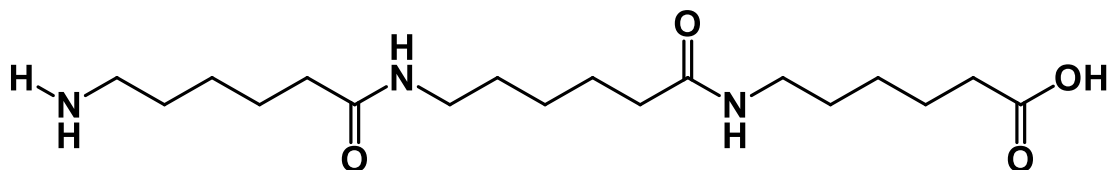
2. The molecules shown below can be used as monomers in a polymerization reaction. They can be drawn in the general form shown to the right. Complete the table below with the identity of R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, and R<sub>4</sub>. The first two rows are filled as an example.



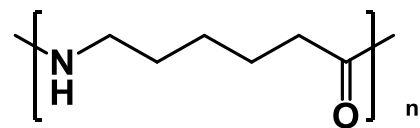
Monomer	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	R <sub>4</sub>
	H	H	H	H
	CH <sub>3</sub>	H	CH <sub>3</sub>	H
	Cl	H	H	H
	H	H	H	CN
	H	CH <sub>3</sub>	H	C(H)(CH <sub>3</sub> )C <sub>6</sub> H <sub>5</sub>

3. Draw the structures of the trimer and of a polymer resulting from the condensation of the monomer below. Name the linkage.

**Trimer:**

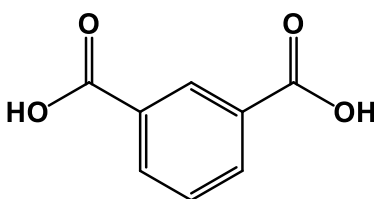
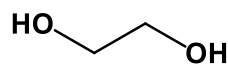
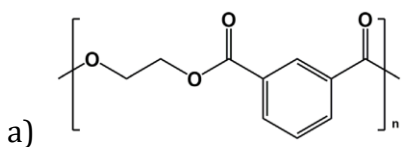


**Polymer:**

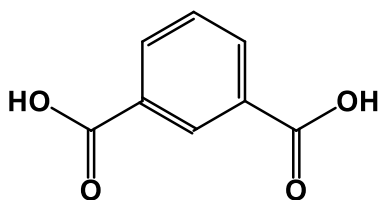
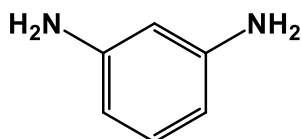
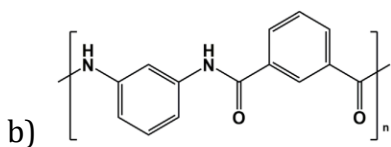


**Amide linkage is formed.**

4. Draw the structure of the smallest possible monomers that correspond to these polymers. Name the type of linkage in the backbone of the polymer. You may draw full Lewis structures, condensed Lewis structures, or line-bond diagrams.

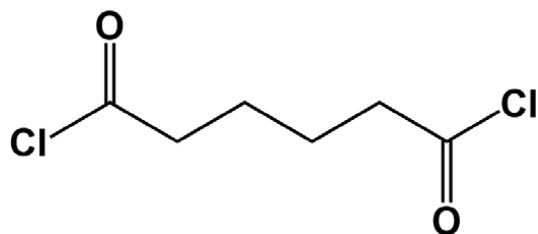


**Ester linkage**

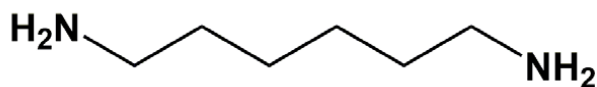


**Amide linkage**

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



Sebacoyl chloride



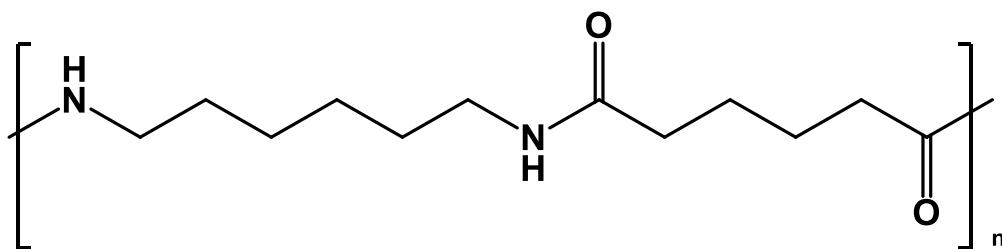
1,6-diaminohexane

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

**The polarity of water and hexanes is significantly different. Water is polar, whereas hexanes are non-polar. The difference in polarity causes the formation of a biphasic mixture. The hydrogen bonding ability of 1,6-diaminohexane makes it soluble in water while the dipoles in sebacoyl are not enough to overcome the non-polar carbon backbone which favours dissolution in hexanes.**

- b) Draw the product(s) of the reaction between sebacoyl chloride and 1,6-diaminohexane. Where does the reaction take place (bottom layer, top layer, at the interface)? Briefly explain.

**Reaction takes place at the interface because that is the only place where the reactants come into contact due to the solubility differences.**

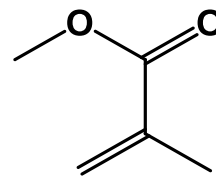
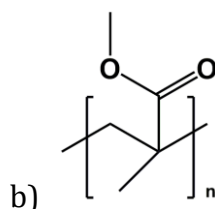
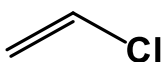
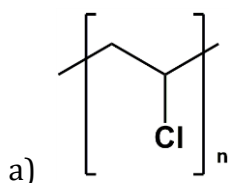


6. **Good Question.** Are polymers most likely solids or liquids at room temperature? Explain why.

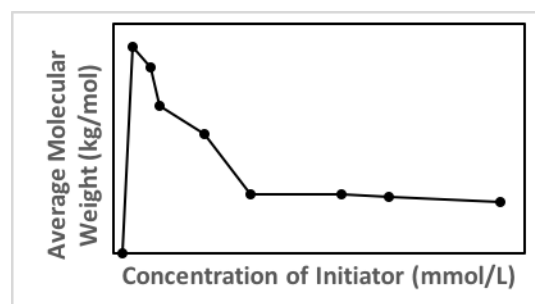
**Polymers are most likely solids at room temperature due to the intermolecular forces they experience. Polarizability is high due to their large size resulting in strong London dispersion forces. Polymers that have a permanent dipole or experience hydrogen bonding are even more likely to be solid, with higher melting and boiling points. Many polymers tend to hold their shape and are resistant to flow at room temperature.**

7. Draw the structure of the smallest possible monomer that corresponds to these polymers. Name the type of linkage in the backbone of the polymer. You may draw full Lewis structures, condensed Lewis structures, or line-bond diagrams.

**Carbon-carbon linkage in both cases**



8. **Good Question.** Provide a valid explanation for the trend in the polymer molecular weight of poly(methyl methacrylate) shown to the right.

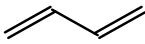
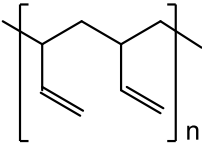
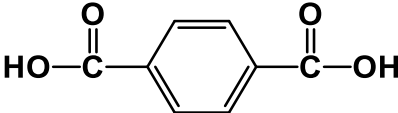
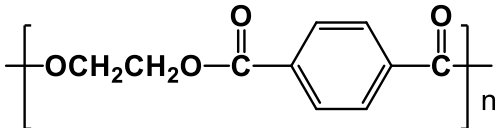
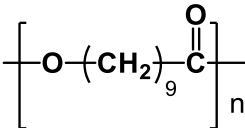
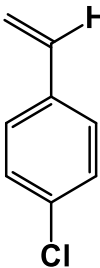
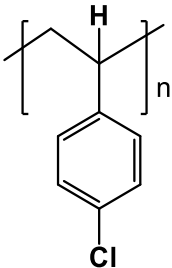
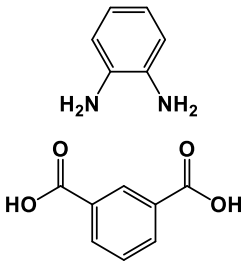
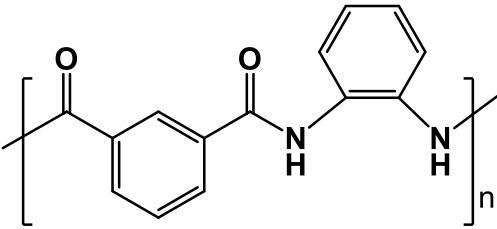
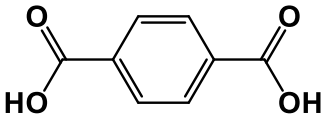
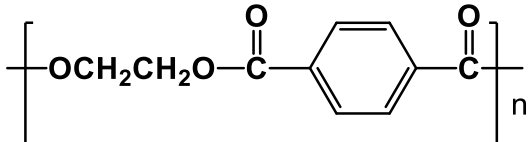


**PMMA is an addition polymer that can be synthesized via radical polymerization. When the concentration of radical initiator is very low, polymerization does NOT occur (molecular weight is zero at the lowest initiator concentration). At some critical initiator concentration, polymerization takes place. Because of the small number of radicals, the termination step is unlikely to occur so the polymers continue to grow very long, reaching high molecular weights. As the concentration of radical initiator increases, the termination step becomes more likely (there are more radicals present) and the chains become shorter (and less massive) as the polymerization process ends sooner.**

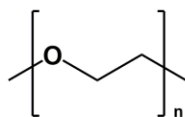
9. **Good Question.** Fill in the blanks in the table below by drawing the monomer or polymer. Classify each polymer as a condensation or addition polymer by circling the correct option. Name the type of linkage.

Monomer	Polymer	Type of Polymerization
		<b>Condensation (Amide)</b>
		<b>Addition (carbon-carbon)</b>
		<b>Condensation (Amide)</b>
		<b>Addition (carbon-carbon)</b>  <b>(Note that condensation cannot happen here)</b>
		<b>Addition (carbon-carbon)</b>

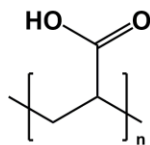
10. **Good Question.** Fill in the blanks in the table below by drawing the monomer(s) or polymer. Classify each polymer as a condensation or addition polymer by circling the correct option. Name the type of linkage.

Monomer(s)	Polymer	Type of Polymerization
<b>**Challenge**:</b> 	 and more possibilities!	<b>Addition (carbon-carbon)</b>
<b>HOCH<sub>2</sub>CH<sub>2</sub>OH</b> 		<b>Condensation (Ester)</b>
<b>HO-(CH<sub>2</sub>)<sub>9</sub>-COOH</b>		<b>Condensation (Ester)</b>
		<b>Addition (carbon-carbon)</b>
		<b>Condensation (Amide)</b>
 <b>HOCH<sub>2</sub>CH<sub>2</sub>OH</b>		<b>Condensation (Ester)</b>

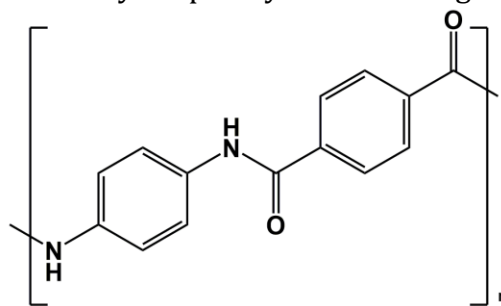
11. Rank the following polymers in terms of increasing flexibility. Explain your reasoning.



A.  
polyethylene glycol  
(PEG)



B.  
polyacrylic acid  
(PAA)



C.  
Kevlar

**In terms of increasing flexibility: C (Kevlar) < B (PAA) < A (PEG)**

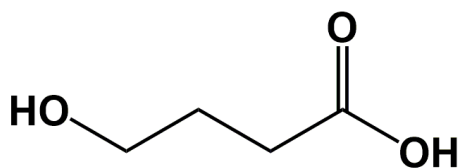
The polymer chains of PEG can easily slide between each other because they have no large substituents extending off the polymer backbone, and the backbone can easily twist because of rotation around the single bonds. Moreover, PEG only experiences London dispersion interactions between the chains. Existing IMFs between chains are broken when a polymer is flexed and new IMFs with other chains are formed. The ease of breaking and reforming weak interactions makes PEG the most flexible plastic of the options.

PAA has a large substituent that can undergo H-bonding between chains. Flexing the polymer requires breaking these H-bonds which requires more energy. Moreover, the H-bonds enhance the formation of small crystalline domains not as prominent in PEG. Breaking these crystalline domains is more energy intensive.

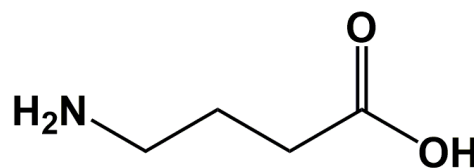
Kevlar is the least flexible of all three polymers. Each repeat unit has four sites for H-bonding which increases the number of crystalline domains and interchain interactions.



12. **Good question.** Which of the following monomers (A or B) produces a polymer with the highest melting point? Briefly explain your reasoning. Assume the molecular weight of the resulting polymer is the same.



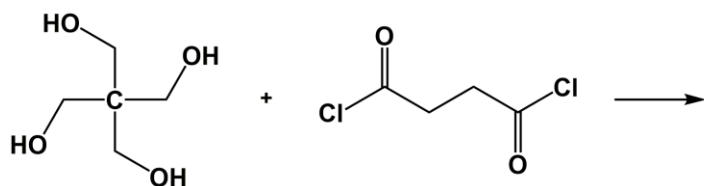
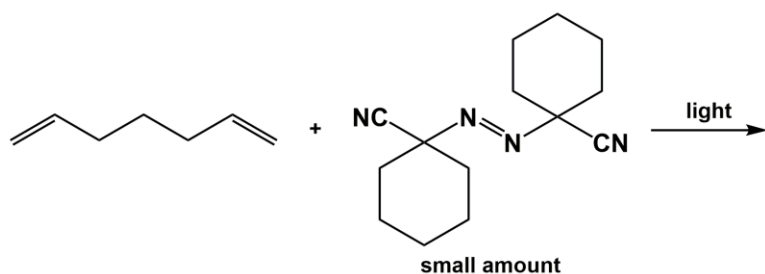
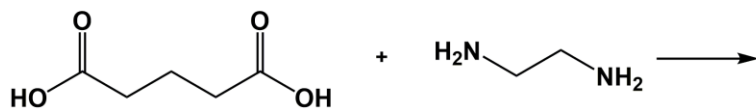
A.



B.

**B has the highest melting point. A polymer of (A) forms an ester linkage whereas a polymer of (B) forms an amide linkage. Amide linkages are capable of Hydrogen bonding between chains and therefore exhibit a higher melting point. (Note that the molecular weight of the polymers is the same, therefore London dispersion forces are expected to be of similar magnitude for both polymers. It's the hydrogen bonding of B that will be important here.)**

13. **Good question.** Which of the following reactions produces a branched polymer?

**branched****branched****linear**