Question #61078 – Chemistry – Organic Chemistry
Question 1. Distinguish between addition and condensation polymers. Give at least two examples for each case.

Answer:
Normally, addition polymerization means that two monomers react with each other and no other small molecules are generaged. The best example is polymerization of ethylene: the double bonds are broken and linked with each other to form a long chain polymer. These are mostly radical based polymerization, for those monomers with double bonds.

Condensation polymerization, as a contrast, normally involves the generation of small molecule products, like water. For example, ethylene glycol reacts with terephathalate to form poly(ethylene terephathalate) polymer. Meanwhile, water is generated. It looks like two molecules "condense" with each other to form this polymer. These include polyester, polyamide and polycarbonate.
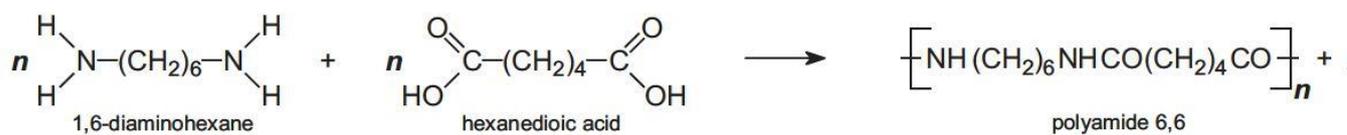
Addition and condensation polymers
In **addition polymerization**, the polymer has the same empirical formula as the monomer but a higher molecular mass (Table 1). An example is the polymerization of chloroethene (vinyl chloride) to form poly(chloroethene), PVC:
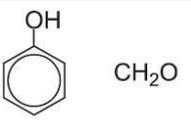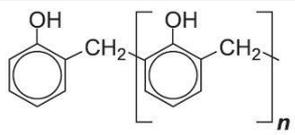

Monomer	Formula	Polymer	Trivial name	Structure
Ethene	$H_2C{=}CH_2$	LDPE Low density poly(ethene)	low density polythene	$-CH_2-CH_2-CH_2-CH_2-$
Chloroethene	$H_2C{=}CHCl$	Poly(chloroethene)	polyvinyl chlorine, PVC	$-CH_2-\overset{Cl}{CH}-CH_2-\overset{Cl}{CH}-$
Propene	$H_2C{=}CH-CH_3$	Poly(propene)	polypropylene	$-CH_2-\overset{CH_3}{CH}-CH_2-\overset{CH_3}{CH}-$
Propenonitrile	$H_2C{=}CH-CN$	Poly(propenonitrile)	polyacrylonitrile	$-CH_2-\overset{CN}{CH}-CH_2-\overset{CN}{CH}-$
Methyl 2-methylpropenoate	$H_2C{=}\overset{CO_2CH_3}{\underset{CH_3}{C}}-CH_3$	Poly(methyl 2-methylpropenoate)	polymethyl methacrylate	$-CH_2-\overset{CO_2CH_3}{\underset{CH_3}{C}}-CH_2-\overset{CO_2CH}{\underset{CH_3}{C}}-$
Phenylethene	$H_2C{=}CH-◯$	Poly(phenylethene)	polystyrene	$-CH_2-CH-CH_2-CH-$
Tetrafluoroethene	$F_2C{=}CF_2$	Poly(tetrafluoroethene) (PTFE)	polytetrafluoroethylene PTFE	$-CF_2-CF_2-CF_2-CF_2-$

Table 1 Some addition polymers.
In **condensation polymerization**, polymerization of one or more monomers is accompanied by the elimination of small molecules (such as water or ammonia) (Table 2). For example, in producing polyamide 6,6, two monomers are used.

n 1,6-diaminohexane $+$ n hexanedioic acid $\longrightarrow$ polyamide 6,6 $+$

Another type of condensation polymer is said to be formed if the polymer chain contains (rather than appended to the chain) a functional group such as an ester, amide or urethane (Table 2).

Polymer	Monomer	Formula
Polyesters	$HO-(CH_2)_x-C\langle{}^O_{OH}$	$\left[(CH_2)_x-\overset{O}{\overset{\|}{C}}-O\right]_n$
Polyamides	$\overset{H}{\underset{H}{N}}-(CH_2)_x-\overset{H}{\underset{H}{N}}$ $\overset{O}{\overset{\|}{C}}-(CH_2)_y-\overset{O}{\overset{\|}{C}}\langle{}^O_{OH}$ HO	$\left[-NH-(CH_2)_{\overline{x}}-NH-\overset{O}{\overset{\|}{C}}-(CH_2)_y-\overset{O}{\overset{\|}{C}}-\right]_n$
Phenol-methanal plastics	phenol (OH on benzene ring) CH_2O	phenol-methanal polymer with $-CH_2-$ links $[\ ]_n$
Polyurethanes	$HO-R^1-OH$ $O=C=N-R^2-N=C=O$	$\left[-R^1-O-\overset{O}{\overset{\|}{C}}-NH-R^2-NH-\overset{O}{\overset{\|}{C}}-O-\right]_n$