

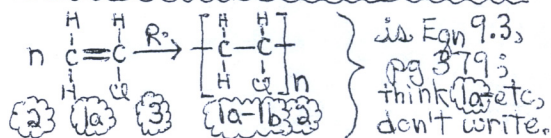
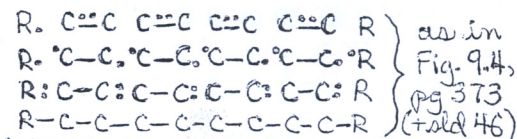
# Quiz 8a

**Functional Groups** are summarized on handout in Learn@UW: alkane (hydrocarbon, only single bonds, C-H); alkanes (family); alkene (with one or more C=C double bonds, but without the alternating C=C's of "aromatics" with benzene...); alkyne. As shown below, categories "split" for O, are "lumped" for N, so more categories for O (alcohols ≠ ethers) than for N (only amines, =); also (carboxylic acid ≠ ester) vs (only amides). Amino Acids have amine-C and acid-C, differ only by R-group; in 108, R is ≈ any group that begins with C, unless it's a C=O.

$\left[ \begin{array}{c} \text{H} \\   \\ \text{H}-\text{O}^+-\text{H} \end{array} \right]^+$ hydronium water $\text{H}-\text{O}-\text{H}$	$\left[ \begin{array}{c} \text{H} \\   \\ \text{H}-\text{N}^+-\text{H} \\   \\ \text{H} \end{array} \right]^+$ ammonium ammonia $\text{H}-\text{N}-\text{H}$   H
R-O-H alcohol	R-N<H   H
R-O-R ether	R-N<R   R
$\begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}=\text{O} \\   \\ \text{OH} \end{array}$ carboxylic acid	$\begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}=\text{O} \\   \\ \text{N}-\text{H} \\   \\ \text{H} \end{array}$ amines
$\begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}=\text{O} \\   \\ \text{O}-\text{R} \end{array}$ ester	$\begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}=\text{O} \\   \\ \text{N}-\text{R} \\   \\ \text{R} \end{array}$ amides

## Addition Polymers

in Lecture 30 (Nov 26, Slides 22-91/end) plus URL on Slide 45, and CiC (371-373, 374-381 with heads/tails on 379-380). Also, my pictures below show: • how 2 electrons in the second bond of C=C help form 2 monomer-connecting bonds in the polymer; • 4-step reminders for writing a condensed equation: **1a** (draw correct monomer structure and related repeating-unit structure with 2 Cs) and **1b** (unit-connecting bonds cross the brackets); **2** (put "n" on left & right sides, with n monomers & n rep-units); **3** (write catalyst over-the-arrow, R•). Use same reminders in rxn-equations for condensation polymers: **1a** for structures of monomer & repeating-unit, **1b** for monomer-linking bonds across brackets; **2**, n for each di-functional monomer on left, n for repeating-unit on right, but 2n H<sub>2</sub>O. **3** puts catalyst (H<sup>+</sup>) over the arrow. / For aa's → polypeptide, #2 has "n H<sub>2</sub>O".



**Addition Polymer:** no atoms lost, polymer = sum of monomers.  
**Condensation Polymer:** lose H<sub>2</sub>O (or...), polymer < sum of m's.

**Condensation Polymers** – explained in Lectures 31-32, in CiC 382-387, and below – are condensed by losing H<sub>2</sub>O (as H, OH) and the "losers" (bond-losing atoms) bonding with each other so they still have correct number of bonds: C (4), N (3), O (2).

In Chem 108 this occurs in two analogous ways, to form an **ester** (from carboxylic acid losing OH, alcohol losing H) or **amide** (from carboxylic acid losing OH, amine losing H), and in similar reactions to form a **polyester** or **polyamide**.

To form a polymer, we need: • two di-functional monomers (di-acid, di-alcohol: polyester) or (di-acid, di-amine: polyamide) with di-acid and di-alcohol each forming bonds to left & right. Later, • two-function monomers (amino acids, w amine & acid on ends); triglyceride (non-polymer), tri-alcohol + 3 fatty acids.

-COOH loses H<sup>+</sup> in acid-base rxn, OH to form ester or amide, which: • is reality (confirmed in experiments using O-isotopes); • lets us think about forming ester & amide in analogous ways.

**ESTER reaction**

$$\begin{array}{c} \text{H}-\text{C}=\text{O} \\ | \\ \text{OH} \end{array} + \begin{array}{c} \text{H} \\ | \\ \text{H}-\text{O}-\text{C}-\text{H} \\ | \\ \text{H} \end{array} \xrightarrow{\text{H}^+} \begin{array}{c} \text{H}-\text{C}=\text{O} \\ | \\ \text{O}-\text{C}-\text{H} \\ | \\ \text{H} \end{array} + \text{H}_2\text{O}$$

↓ loses HOH

ESTER BOND ← E- O ← E- R-OH

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**AMIDE reaction**

$$\begin{array}{c} \text{H}-\text{C}=\text{O} \\ | \\ \text{OH} \end{array} + \begin{array}{c} \text{H} \\ | \\ \text{H}-\text{N}-\text{C}-\text{H} \\ | \\ \text{H} \end{array} \xrightarrow{\text{H}^+} \begin{array}{c} \text{H}-\text{C}=\text{O} \\ | \\ \text{O}-\text{N}-\text{C}-\text{H} \\ | \\ \text{H} \end{array} + \text{H}_2\text{O}$$

↓ loses HOH

ESTER BOND ← E- O ← E- R-NH

**DI-ACID DI-ALCOHOL DI-ACID DI-ALCOHOL**

monomers

polymer (polyester)

repeating unit of PETE

REPEATING UNIT

$n \begin{array}{c} \text{O} \\ || \\ \text{---C---} \\ | \\ \text{OH} \end{array} + n \begin{array}{c} \text{H} \\ | \\ \text{HO}-\text{C}-\text{H} \\ | \\ \text{H} \end{array} \xrightarrow{\text{H}^+} \left[ \begin{array}{c} \text{O} \\ || \\ \text{---C---} \\ | \\ \text{O}-\text{C}-\text{H} \\ | \\ \text{H} \end{array} \right]_n + 2n \text{H}_2\text{O}$

Why does eqn have 2n H<sub>2</sub>O? } di-acid plus di-alc

$n \text{ REP-UNITS} \left( \frac{2 \text{H}_2\text{O}}{\text{REP-UNIT}} \right) = 2n \text{H}_2\text{O}$

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**DI-CARB acid DI-AMINE DI-CARB acid DI-AMINE**

monomers

polyamide

REP-units of Nylon-66

REPEATING UNIT

$n \begin{array}{c} \text{O} \\ || \\ \text{---C---} \\ | \\ \text{OH} \end{array} + n \begin{array}{c} \text{H} \\ | \\ \text{H}-\text{N}-\text{H} \\ | \\ \text{H} \end{array} \xrightarrow{\text{H}^+} \left[ \begin{array}{c} \text{O} \\ || \\ \text{---C---} \\ | \\ \text{O}-\text{N}-\text{H} \\ | \\ \text{H} \end{array} \right]_n + 2n \text{H}_2\text{O}$