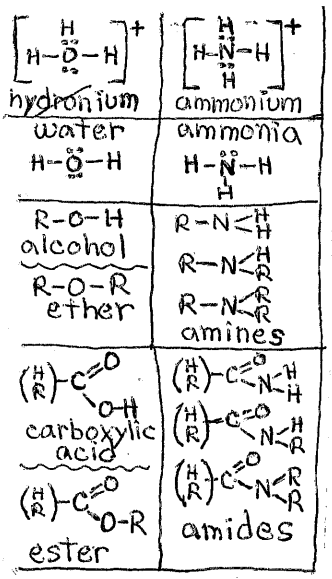
Quiz 8a

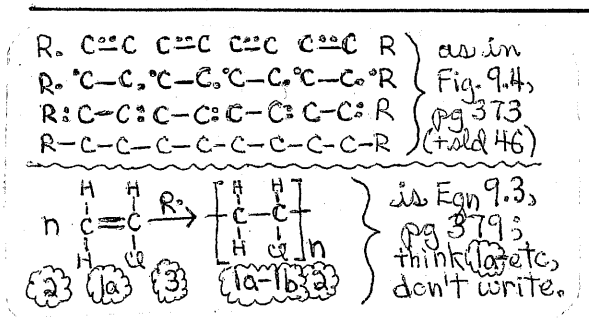
Functional Groups are summarized on handout in Learn@UW:
- alk**ane** (hydrocarbon, only single bonds, C-H); alkan**es** (family);
- alk**ene** (with one or more C=C double bonds, but without the alternating C=C's of "aromatics" with benzene...); alk**yne**.

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.



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_2O. **3** puts catalyst (H^+) over the arrow. / For aa's → polypeptide, #2 has "n H_2O", NEXT WEEK.



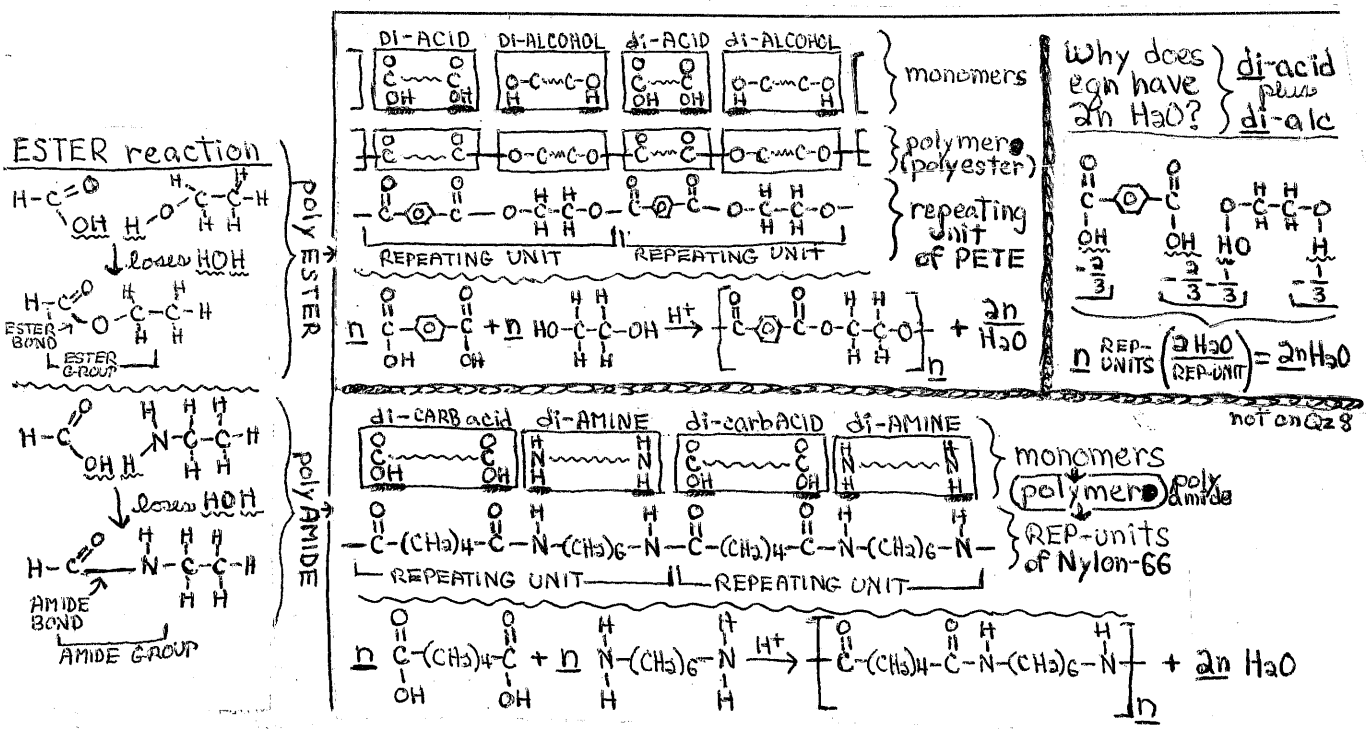
Addition Polymer: no atoms lost, polymer = sum of monomers.
Condensation Polymer: lose H_2O (or...), polymer < sum of m's.

Condensation Polymers – explained in Lectures 31-32, in CiC 382-387, and below – are *condensed* by losing H_2O (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 poly**ester** or poly**amide**.

To form a polymer, we need: • two di-functional monomers (di-acid, di-alcohol: poly**ester**) or (di-acid, di-amine: poly**amide**) 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.

-CO**OH** loses H^+ 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.



Quiz 8b

Condensation Polymers: on "Quiz 8a", bottom-of-page pics show how di-**monomers** form **polymers** with **repeating-units**. How to decide rep-units: CiC (p 387) shows "parts that leave" (OH, H) in red. Remove these parts (they form HOH) and what survives (i.e. non-red parts) form repeating-unit in rxn-equation. For polyester, use p 384 (imagine the far-left OH and far-right H are red, as on 387); or use the top-row middle molecule on 385.

PETE NYLON-66

You should know reactions by names of functional groups; e.g., carboxylic acid + alcohol → ester + water } (names: propanol, carboxylic acid + amine → amide + water } propanoic acid,...)

Heads and Tails (379-380, slides 69-83) can have "rhythms" of 1 • 3 • (for head-to-tail, head-to-tail), or Random (no pattern), or 1 2 • • (head-to-head, tail-to-tail); only connectivity matters, so ignore irrelevancies in drawing structural formula (e.g. slide 75).

Examples of Polymers: **Addition Polymers** vary in "x" group, polyethylene (x = –H), polypropylene (–CH_3), polystyrene (–⬡), polyvinyl chloride (–Cl). These, including two polyethylenes (LDPE & HDPE), are five of The Big Six, page 378. The other is a **Condensation Polymer**, the **polyester** PETE (aka PET); a common **polyamide** is Nylon-66; structures are on *Quiz 8a.*

Reactions & Energy

Endothermic: uphill (Products-E > Reactants-E), E-change is +.
Exothermic: downhill (Products-E < Reactants-E), E-change –.

Endothermic: T decreases, so (because it's cool) it absorbs E.
Exothermic: T increases (**ex**plosion is **ex**othermic) so releases E.

Endo-rxns (split of O_2, O_3...) occur, but Exo-rxns more common.

Acid-Base Neutralization Rxns: see top of handout for Exam 3.

↑ of octane → energy of rxn ↑

Gasoline Additives: ~~lead~~ (NO), [partial MTBE, temp] (YES) ethanol increase octane (over 60-70 off tower) to reduce knocking, 178-181; emissions of CO reduced by oxygenates (MTBE, ethanol) but we get less energy because are partially oxidized; oxidn of C & H → E, but not O.
(burned) CO_2 H_2O

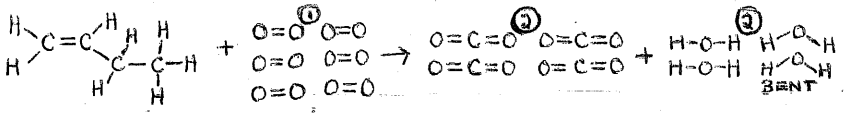
Cracking → more gasoline (higher price) but → alkenes (due to conservation of H) that → engine deposits; **thermal** (E input, alkenes), **catalytic** (~~E input~~, alkenes), **hydro** (~~E input~~, ~~alkenes~~).

Using Bond Energies to Calculate Reaction Energies

Step: words → molecules (Translation)

Step 1: write balanced rxn-equation (if CH_3COOH, be careful);
Step 2: draw Lewis Structures, especially fuel; 2 for CO_2 H_2O.
Step 3: do math systematically, for you (to get correct answer) and for grader (write clear "essay" to show your work).

To find energy of combustion for 1-butene, Step 1: $1\ CH_2CHCH_2CH_3 + 6\ O_2 \rightarrow 4\ CO_2 + 4\ H_2O$, Step 2: draw Lewis structures,



Step 3:

8 moles C–H (416 kJ/mole) = 3328 kJ
1 mole C=C (598 kJ/mole) = 598 kJ
2 moles C–C (356 kJ/mole) = 712 kJ
6 moles O=O (498 kJ/mole) = 2988 kJ
TOTAL = 7626 kJ

8 moles C=O (803 kJ/mole) = 6424 kJ
8 moles H–O (467 kJ/mole) = 3736 kJ
TOTAL = 10160 kJ

+(7626 kJ) –(10160 kJ) = – 2534 kJ / mole C_4H_8

Know all lab-calculations, like this:

$$\frac{-2534\ \text{kJ}}{\text{mol}\ C_4H_8}\left(\frac{1\ \text{mol}\ C_4H_8}{56.12\ \text{g}\ C_4}\right) = \frac{45.15\ \text{kJ}}{\text{g}\ C_4H_8}$$

Practice Problems with Answers: for **CH_4** (Lec 29, slides 63-71-78-79; Lec 30, slides 5-20), **H_2** (CiC, 175-178), **C_2H_2** (page 178), and **more** (#19 on page 195, answers on page A-20), plus **Exam 3** from 2011 (Part 4, #3; also know #4 from your Energy Lab), and **Exam 4** from 2012 (Part 2, #2); also know Part 2, #1, and #3-4 from Energy Lab.