Exam 4 — to supplement **Quiz 8a-8b** and **8c**

Addition Polymers — Heads and Tails

The "spatial rhythm" is defined (and can be seen) in each name:

Head-to-Tail, Head-to-Tail				Head-to-Head, Tail-to-Tail			
1	-	3	-	1	2	-	-

Page 379 suggests "arbitrarily thinking of" the carbon-with-H as Head, but this is arbitrary. To make the rhythms 1-3- (not -2-4) and 12- - (not - -34), I prefer to define C-with-the-large-group (CH_3, Cl, ⬡) as Head because the names — "Head-to-Tail..." and "Head-to-Head..." — are fixed by tradition, not by me.

Polymerization — What is required?

To form a polymer, monomers must react to-**L**eft and to-**R**ight.
For **addition polymer**, L-and-R happens with C=C of alkene.
For **polyester**, use di-acid (L, R) plus di-alcohol (L, R); {8a}
for **polyamide**, use di-acid (L, R) plus di-amine (L, R), {8a}

and later, on Quiz 9 — it's after Exam 4, so ignore it now. *
for ***polypeptide***, use amino acids (amine on L, acid on R).
For *triglyceride* (a non-polymer), use 3 acids plus tri-alcohol.

Big Six (p 378): know structure & names, properties → uses.

problems of recycling PVC: additives; burning → HCl, dioxin.

Structures of Monomers for:

addition (p 378 shows similarity of monomers for polyethylene (HDPE, and LDPE with more branching, → properties ≠); polypropylene, polyvinyl chloride, polystyrene .

polyester: PolyEthylene Terephthalic Ester (PETE, aka PET); p 378: ethylene glycol is 2-C di-alcohol with OH on each C; terephthalic acid [ph,th] is benzene with symmetric di-acid).

polyamides: Nylon-6,6 (p 386, has 6 C in di-acid & di-alcohol), Kevlar (p 387, benzene with symmetric di-acid & di-amine);
Quiz 8a has repeat-units and rxn-eqtns for PETE & Nylon-6,6.

and later, analogous applications of these ideas for Quiz 9,
polypeptides: variety of Amino Acids (amine on left end, carboxylic acid on right end) with differing R-groups.
triglycerides (fats/oils) non-polymer: glycerol, 3-C tri-alcohol (p 354) plus 3 fatty acids with variety as explained on 452-461, where one factor is saturated (no C=C) vs unsaturated (w C=C).

Hydrogenation Reaction: $>C{=}C< + H_2 \xrightarrow{\text{(catalyst)}} >CH\text{-}CH<$

Catalyst (over-the-arrow) speeds up reaction but is not reactant or product in rxn-equation. In rxns: **R•** for addition polymers, **H⁺** for condensation (ester & polyester, amide & polyamide, *and later – after Exam 4* – to make *polypeptides* and *triglycerides*).
For other reactions (catalytic cracking, hydrocracking, adding H across C=Cs), in Chem 108 it's just an undefined "**catalyst**".

Writing Condensation Reactions — a step-by-step strategy uses Steps (0,1,2,3) analogous to Addition Polymerization {8a}.
Step 0: Translate from words (formic acid,...) into structures.
Step 1a: RED - find atoms that leave: OH of COOH, H of OH.
BLUE - find **atoms that lose bonds**: **C** of COOH, **O** of OH.
BLUE - on right side, bond **C** (of C=O) with **O** (of OH), and
BLACK - copy all non-Red/Blue atoms from left to right.
RED - combine "lost" OH and H to form HOH (i.e. H_2O).
For ester-reaction, stop here; for polyester-reaction, do 1b-2-3.
Step 1b: draw brackets for repeating-unit; remove remaining Red-atoms (OH, H) so you can draw bonds-across-brackets.
Step 2: n di-acids + n di-alcohols → n repeating-units, 2n H_2O.
Step 3: For ester or polyester, H^+ (a catalyst) over-the-arrow.

• Use same steps if alcohol (-OH) is replaced by amine (-NHx); replace H (of OH) by H (of NH_2), and **O** (of OH) by **N** (of NH_2); and product (ester or polyester) is now amide or polyamide.

If "given product, find reactants", use blue+black/red back-logic: find **blue** atoms (**C**=O, **O**H), un-bond **blue**, copy black, add red.

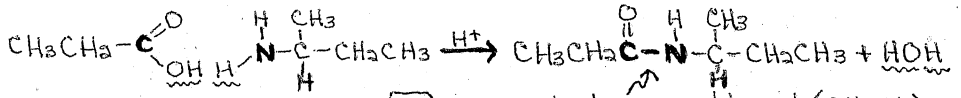
and later — for Quiz 9,
• Use same steps if di-acid/di-amine (for polyamide) is replaced by amino acids (for *polypeptide*); the main differences are the monomer & repeating unit (both have an R-group that can vary), and for Step 2 only n H_2O is produced, instead of 2n.

• **carbohydrates:** name from $C_n(H_2O)_n$ of CH_2O monomers.
• **saccharides** (mono/di) dissolve in water (very polar) due to functional groups — ethers (polar) and alcohols (very polar) — but are non-electrolytes, don't form ions or conduct electricity.
• flowchart in Slide 38 (Lec 33) is a great overview, showing **mono**saccharides (glucose, fructose), **di**saccharides (sucrose,...), and **poly**saccharides (starch, cellulose), with **1, 2, n** monomers.
• Humans more easily digest disaccharides or polysaccharides with α-linkages (rings on ≈ same plane), not β-linkages (w rings on different planes); in Slides 34-40, maltose (α) vs lactose (β), starch (α) vs cellulose (β).
• HFCS (glucose, fructose) vs sucrose (glucose-and-fructose).
(mixture of monosaccharides) (molecule disaccharide)

Energy-Math for **Energy Lab:** Know calculations from E-Lab and in Exam 3 of 2011 (Part 4, #4), Exam 4 of 2012 (Part 2, #4):
Heat Absorbed = (__ g **H_2O**)(T_f-T_i deg)(4.184 J/g-deg) = __ J ;
Exp Heat of Rxn = (__ Abs-Heat in J) /__ g fuel) = J / g of **fuel** ;
find Efficiency (p 11-5); use Efficiency (p 11-4) to get corrected Heat of Rxn = __ J / g fuel, and {1000 J = 1 kJ} in __ kJ / g fuel.

* This handout is for Exam 4, so *why does it include ideas from after it?* To *emphasize the unity of ideas & chemistry;* a wide range of applications – using condensation reactions in industry and biology – are minor variations on the same basic themes.

A. On Quiz 8c, do #7b except with amine instead of alcohol.
B. What reactants will form the product of Problem A?
C. Write reaction-equation to make Kevlar. (above, or pg 387) (■ on left)

A 

B separate here, add red (OH, H)

■ C