Chemistry 212 — Fall Semester 1996

The Final Learning Experience

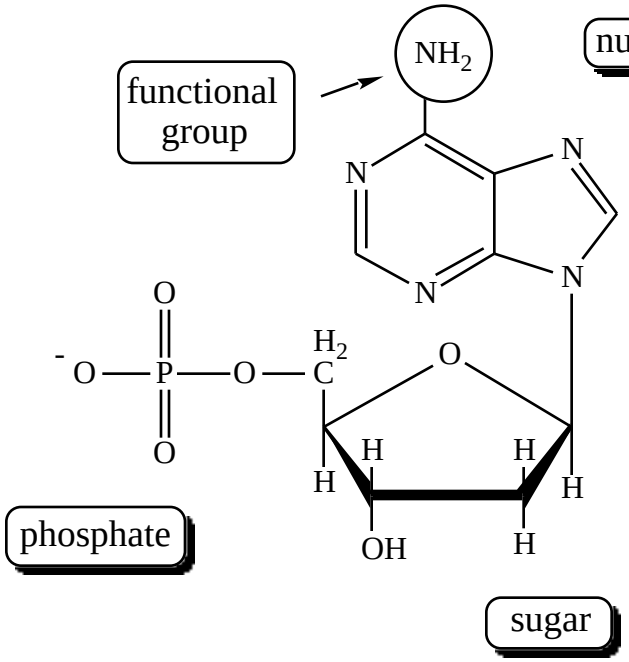
University of Missouri—Columbia, Prof. Rainer Glaser
Monday, December 9, 1996, 103 Schlundt Hall, 12:40 - 2:30

Your Name:
Herr Dr. Rainer Glaser

	Max.	Yours
Question 1 (Sugars)	55	
Question 2 (Alkenes)	70	
Question 3 (Carbenes)	25	
Question 4 (Benzenes)	50	
Total	200	

Do not turn the page until advised to do so.

Question 1. Sugar Structure and Stereochemistry. (55 points)
(Recognition, Stereochemistry, Functional Group Chemistry, Evaluation)



2' deoxyadenosine-5' monophosphate

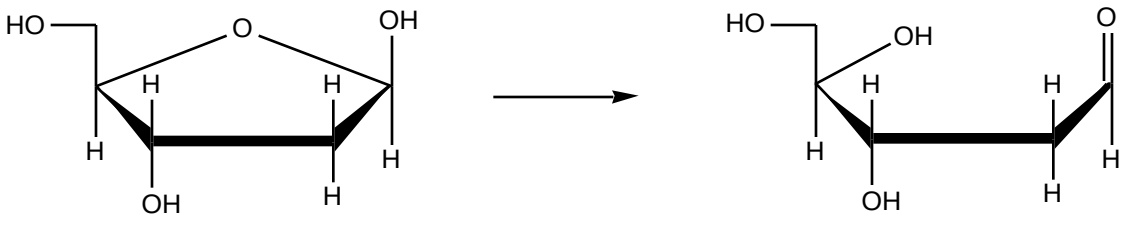
dAMP

A monomeric piece of a DNA polymer

(a) In the syllabus, the above picture was shown. With what we have learned in the last few months, we can now understand much more about this piece of DNA. Let's begin with a look at the sugar moiety contained in dAMP. The sugar in dAMP is a ____pentose___ (tetrose, pentose, hexose, heptose). The sugar in dAMP is a _____furanose____ (furanose, pyranose). (8 points)

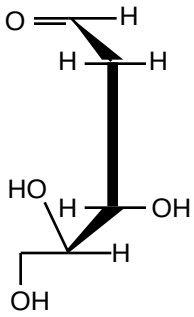
(b) Below, the Haworth formula is shown of the sugar in dAMP after removal of the nucleobase and of the phosphate. Indicate the C-atom that gives rise to epimers during the hemiacetal formation and indicate whether the epimer shown is the **alpha or beta epimer**. Furthermore, disconnect the hemiacetal and show the **open form** of the sugar. (11 p., 6 for alpha/beta, 7 for open form)

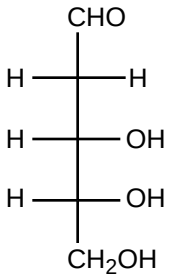
The Open Form of the Sugar



alpha or beta? _____beta____

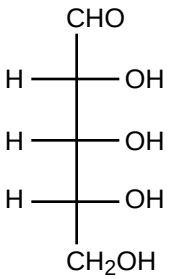
(c) Draw the **Fischer Projection** of the open form of the sugar shown in (b). Indicate whether this stereoisomer of the sugar is **D** or **L**. (12 points)





D

(d) Draw the **Fischer projection of ribose**. Just in case you forgot the Fischer projection of ribose, the correct IUPAC name of ribose is (2R,3R,4R)-2,3,4,5-tetrahydroxypentanal. State the structural difference between ribose and the sugar dealt with above. Does the name **2-deoxyribose** fit for the sugar in dAMP? (12 points)



Difference: Ribose is oxidized at C2. One more OH group.

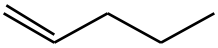
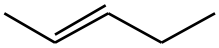
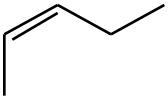
(e) Epimerism constitutes a special case of ____diastereoisomerism_____ in that epimers are stereoisomers that differ only in the configuration of one chiral carbon. State whether the **optical activities of epimers** are the same or whether they are different. Make a statement about the magnitude (same or different) and the sign (same or different). Define the term "mutarotation". (10 points)

different in magnitude
can be different in sign
they could be the same accidently.

the change in optical activity associated with equilibration of epimers.

Question 2. Wittig Reaction and Hofmann Elimination. (70 points)
(Geometrical Isomerism, Synthesis, Mechanisms, Electronic Structures)

(a) Let's look at making structural isomers of pentene. There are two of them: 1-Pentene and 2-pentene. Draw the structure of 1-pentene. 2-Pentene can form two geometrical isomers and one of these is shown. Draw the structure of the other geometrical isomer as well and label the geometrical isomers both with the *cis/trans* and with the *E/Z* nomenclatures. (14 points; 3 per structure, 2 per label)

	1-pentene	isomer 1 of 2-pentene	isomer 2 of 2-pentene
			
cis or *trans*:		*trans*	*cis*
E or *Z*:		E	Z

(b) Suppose you are given **2-bromopentane**. Which of the isomeric pentenes can you synthesize from this starting material by way of a simple base-catalyzed elimination? Suggest a base to use. Clearly state what products are formed and which ones are major and minor, respectively. Finally, explain why the major product is formed preferentially. (16 points: 2 for base, 6 points for products, 4 points for deciding minor/major, 4 points for explanation of major.)

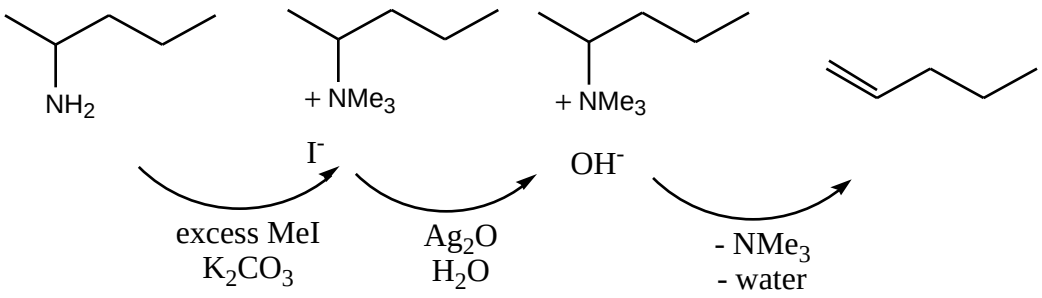
Base: sodium ethoxide (for example)

Products: small amounts of 1-pentene, 2-pentene is clearly preferred.
among the 2-pentenes, the trans isomer is preferred.

Mechanism: E2 leads preferentially to the more substituted olefin for well-know reasons.

(c) Suppose you are given **2-aminopentane** and you subject this amine to **Hofmann elimination**. First write down the overall reaction (include the intermediate quaternary ammonium salt in the overall reaction) clearly showing all reagents and all products. Second, show the mechanism for the formation of the quaternary ammonium ion. Third, specify what type of elimination mechanism is operative in the Hofmann elimination (E1, E1cb, E2) and explain the preferential formation of the ____less_ (more, less) substituted alkene. (20 points for this part)

Overall reaction (8 points):



Mechanism of quaternary ammonium ion formation (6 points):

add methyl cation to form ammonium ion
loose proton to get monomethylated amino derivative

add methyl cation to form ammonium ion
loose proton to get dimethylated amino derivative

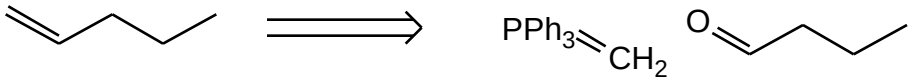
add methyl cation to form quaternary ammonium ion (no more Hs left!)

Explanation (4 points):

The E1cB type mechanism gives the less substituted alkene.

(d) Suggest a synthesis of 1-pentene via the Wittig reaction. In principle, there are two ways to disconnect the 1-pentene. Of these possibilities, consider only that possibility that employs butanal as one of the reagents in the Wittig reaction. First, describe the formation of the ylide (structures and reagents) and draw all relevant resonance structures for the ylide. Second, show the reaction between the ylide and the carbonyl compound. (20 points)

Ylide formation:

Retro: 

$MeBr + PPh_3$ -----> $[MePPh_3]^+ + Br^-$

$[MePPh_3]^+ Br^- + BuLi$ -----> $H_2C{=}PPh_3 + BuH + LiBr$

Resonance forms for Ylide:

The phosphorane $H_2C{=}PPh_3$

The carbanion $H_2C(-)\text{-}(+)PPh_3$

Wittig reaction:

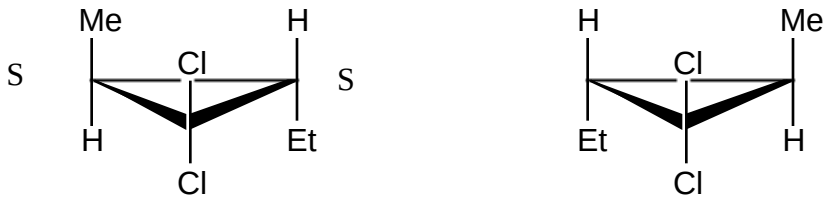
aldehyde plus ylide exchange their double bonds

want to see 4-membered ring intermediate

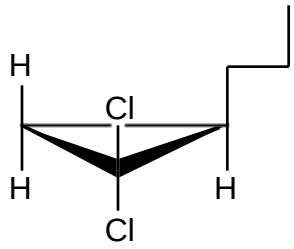
betaine is fine but not required

Question 3. Carbenes. (25 points)
(Cyclopropane Synthesis, Amine Nitrosation, Carbene Synthesis and Reactivity)

(a) The reaction of chloroform and *trans* 2-pentene in the presence of *tert.*-BuOK in the solvent *tert.*-BuOH yields a **racemate of enantiomeric cyclopropane derivatives**. Draw the structures of both of these enantiomers formed and specify the absolute configuration of all asymmetric C-atoms present in **one** of these enantiomers. (14 points; 4 each structure, 6 for R/S labels)



(b) The reaction of chloroform and 1-pentene in the presence of *tert.*-BuOK in the solvent *tert.*-BuOH also yields a cyclopropane derivative. Draw the structure of this cyclopropane. Is this structure chiral or is it not chiral? (7 points)



chiral

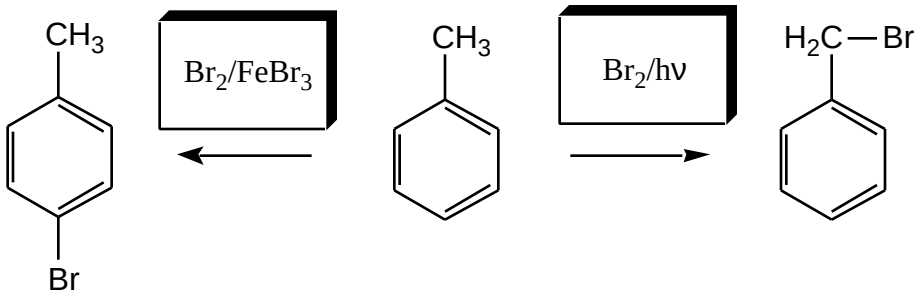
(c) Suggest a synthesis of diazomethane. (4 points)

treatment of N-methyl-N-nitrosourea with KOH in ether (see chapter 21)

Question 4. Aromatic Substitutions and Chemistry of Benzenes. (50 points)

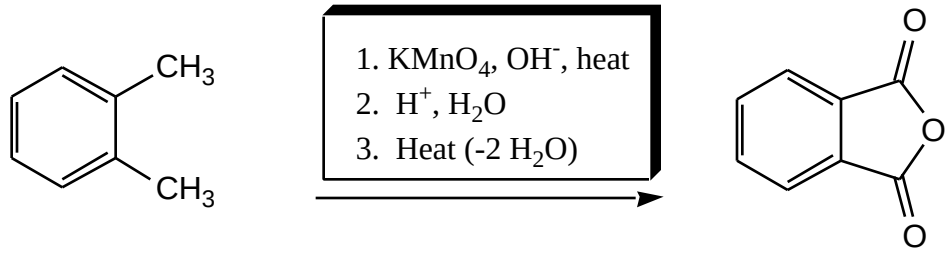
Provide structures of starting materials, products and reagents as needed. Answer the additional question. (10 points each item)

(a) Provide reagents and specify the mechanisms operating in each case.



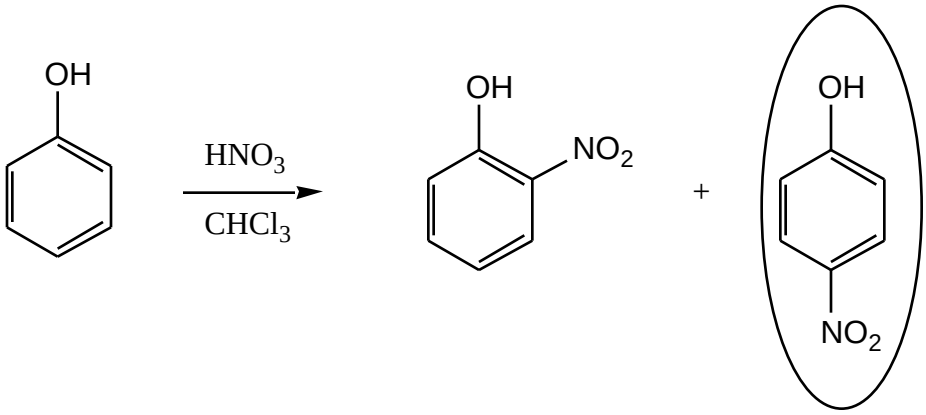
Left: Electrophilic aromatic substitution — Right: Radical chain bromination

(b) Provide the trivialname of the starting material. Name the functional group in the product.

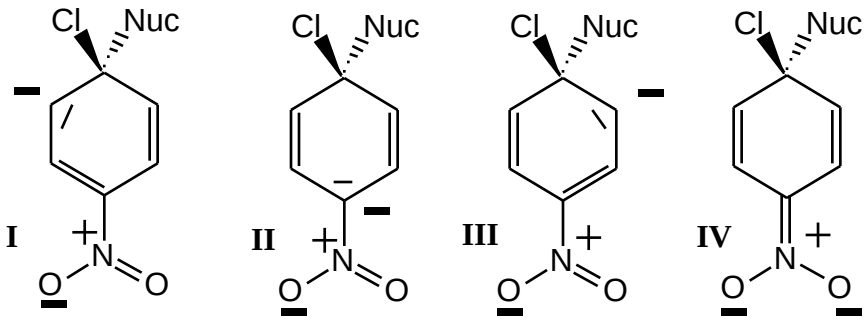


ortho-xylene carboxylic acid anhydride

(c) Show all products and circle the major product.

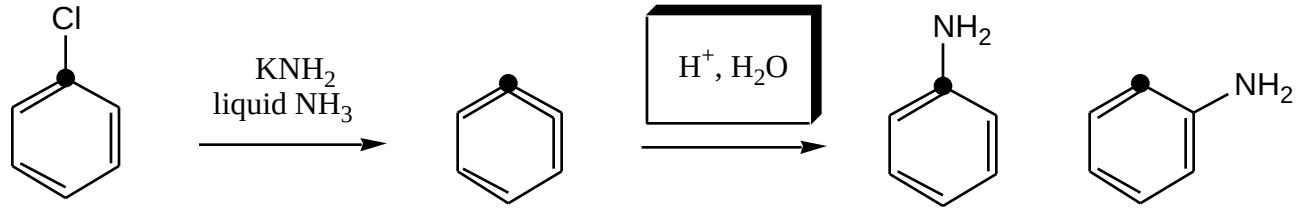


(d) *Para*-nitrochlorobenzene undergoes nucleophilic aromatic substitution faster than *meta*-nitrochlorobenzene. Show all resonance forms for the intermediate of the faster reaction. Then explain.



Quinoid form **IV** not possible in the other case.

(e) Show the structures of the intermediate and of the products.



carbon-14 label
in ipso position

"I have also benefited from teaching: as I try to explain my views to students with critical and open minds, I find myself continually challenged to go back and rethink ideas. I now see teaching and research as complementary, mutually reinforcing activities."
Mario J. Molina in his Nobel Lecture
Angew. Chem. Int. Ed. Engl. **1996**, *35*, 1779-1785.

The End