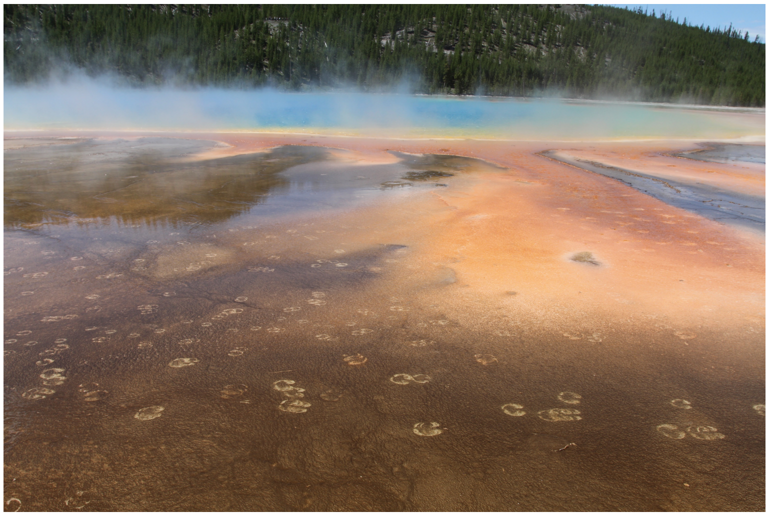
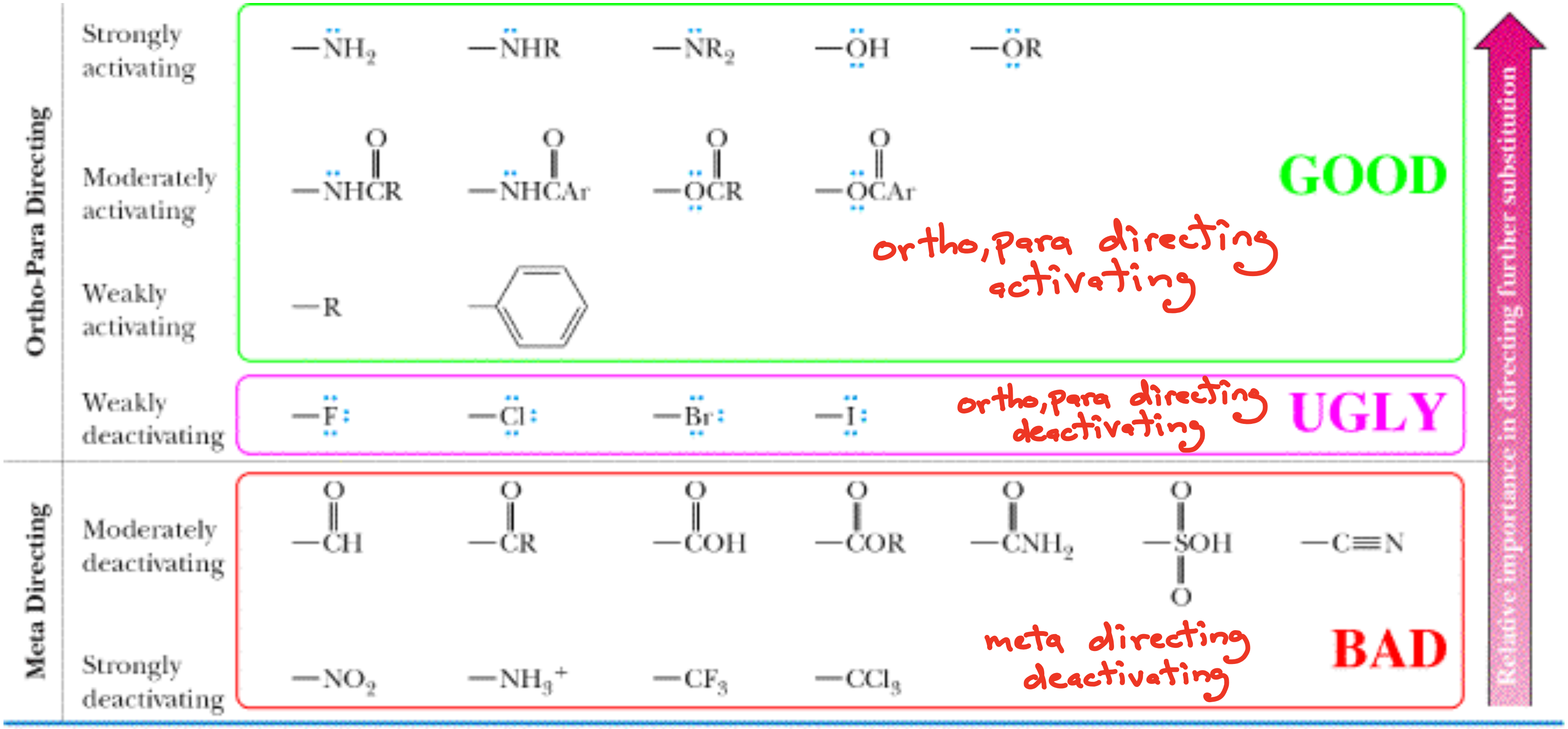




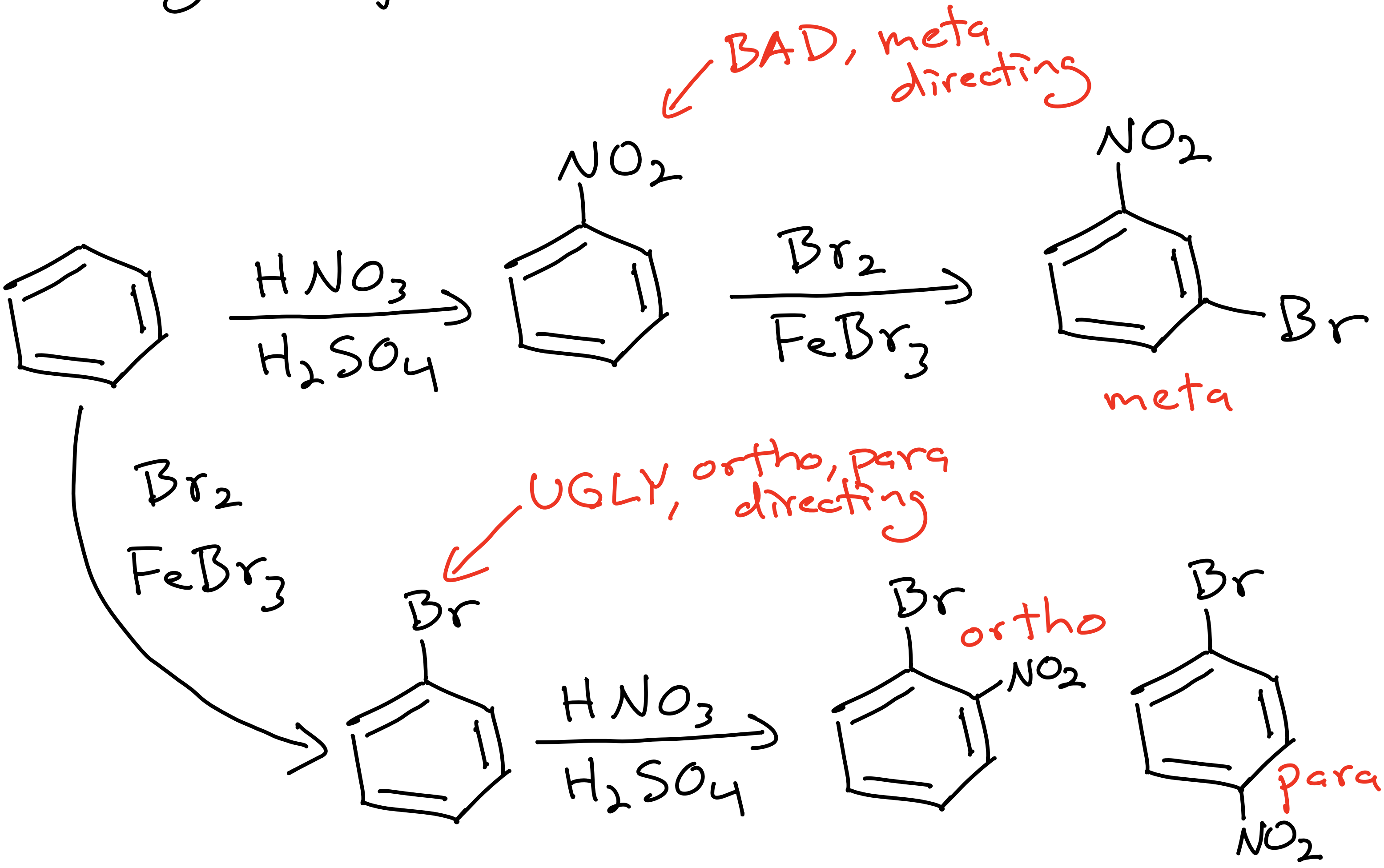





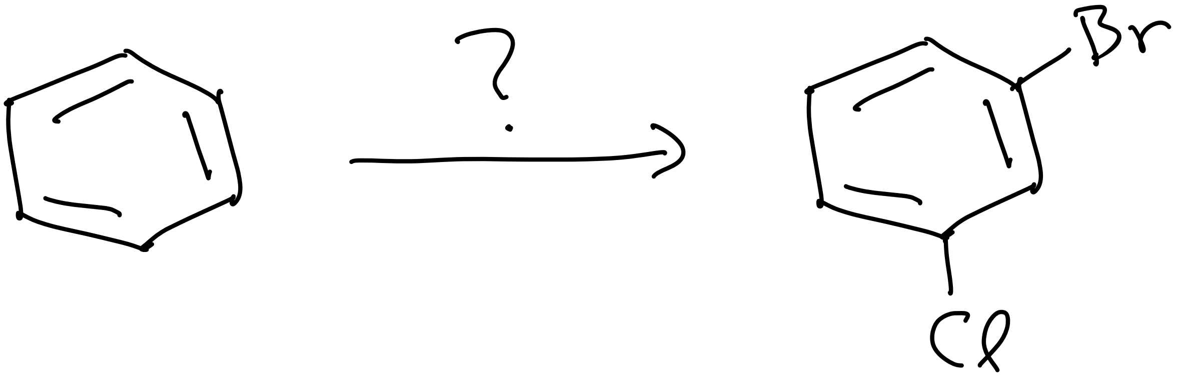



Ortho-Para Directing	Strongly activating	$-\ddot{N}H_2$	$-\ddot{N}HR$	$-\ddot{N}R_2$	$-\ddot{O}H$	$-\ddot{O}R$			
	Moderately activating	$-\ddot{N}H\overset{O}{\overset{\|}{C}}R$	$-\ddot{N}H\overset{O}{\overset{\|}{C}}Ar$	$-\ddot{O}\overset{O}{\overset{\|}{C}}R$	$-\ddot{O}\overset{O}{\overset{\|}{C}}Ar$				**GOOD** ortho,para directing activating
	Weakly activating	$-R$	$-C_6H_5$						
	Weakly deactivating	$-\ddot{F}:$	$-\ddot{Cl}:$	$-\ddot{Br}:$	$-\ddot{I}:$				ortho,para directing deactivating **UGLY**
Meta Directing	Moderately deactivating	$-\overset{O}{\overset{\|}{C}}H$	$-\overset{O}{\overset{\|}{C}}R$	$-\overset{O}{\overset{\|}{C}}OH$	$-\overset{O}{\overset{\|}{C}}OR$	$-\overset{O}{\overset{\|}{C}}NH_2$	$-\underset{\underset{O}{\|}}{\overset{O}{\overset{\|}{S}}}OH$	$-C\equiv N$	
	Strongly deactivating	$-NO_2$	$-NH_3^+$	$-CF_3$	$-CCl_3$				meta directing deactivating **BAD**

The order in which you add groups matters!



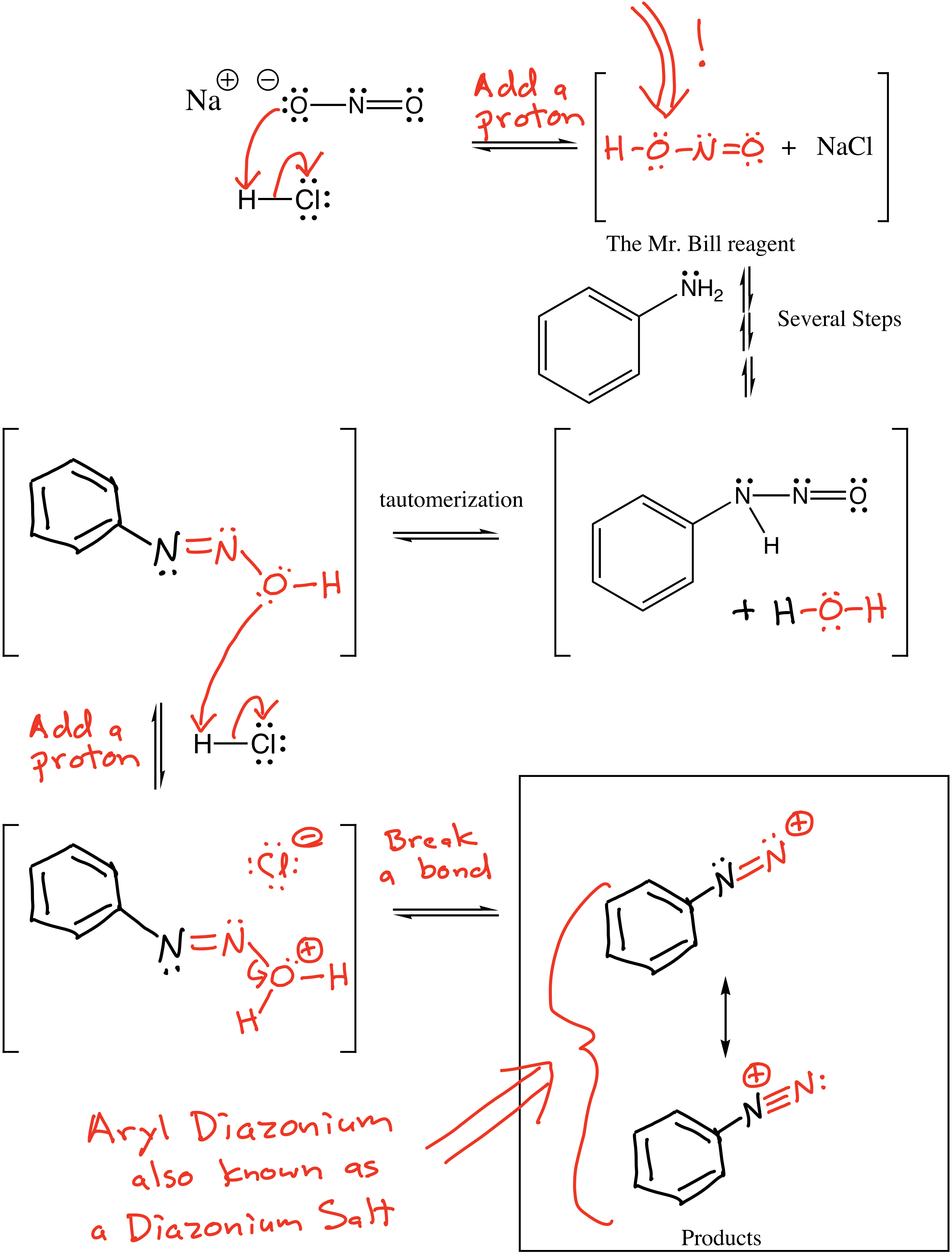
How do we carry out the following synthesis?



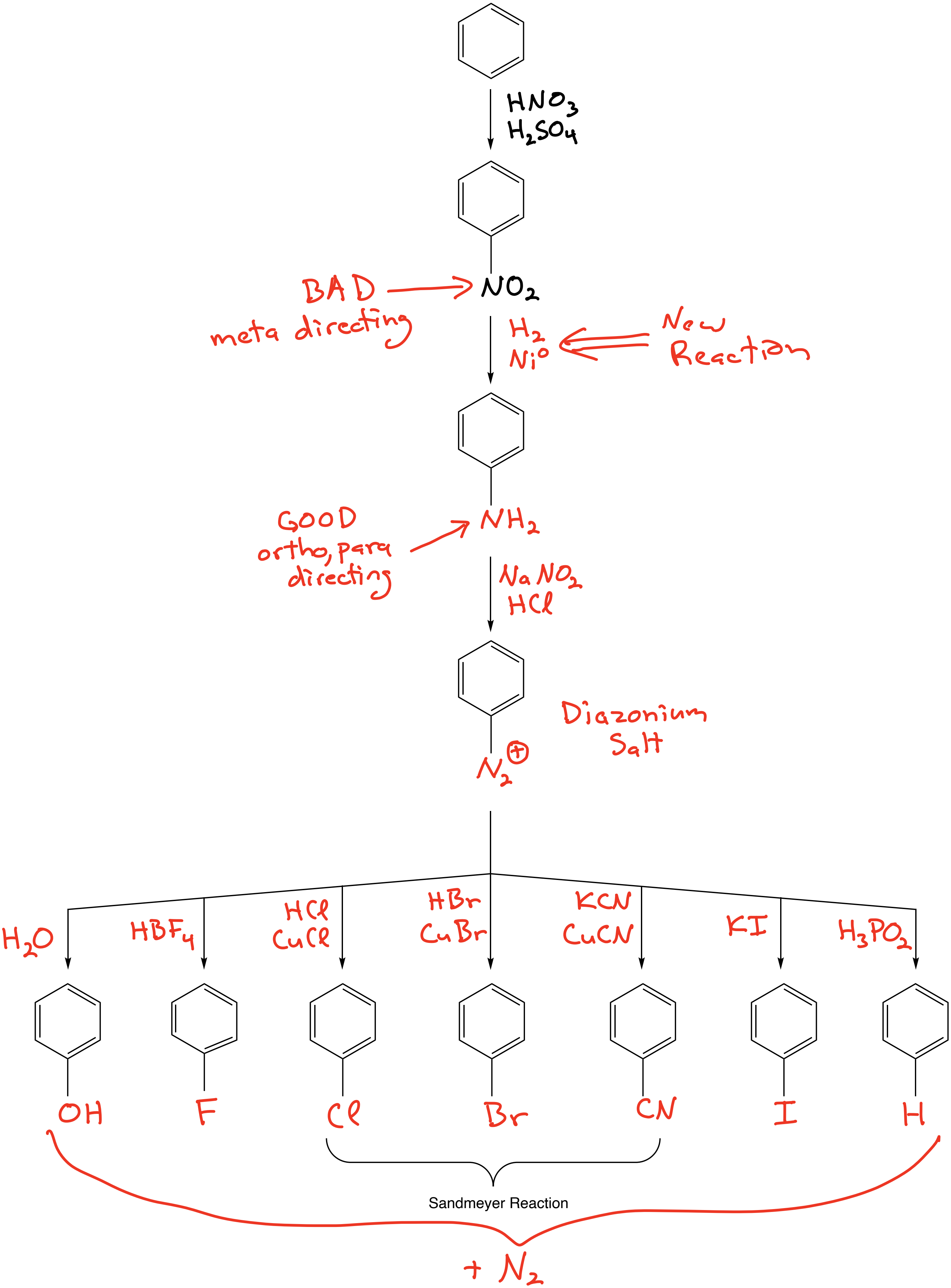
Time to call "Mr. Bill"

Both of these are UGLY so they are ortho, para directing. How do we introduce both of them meta to each other?

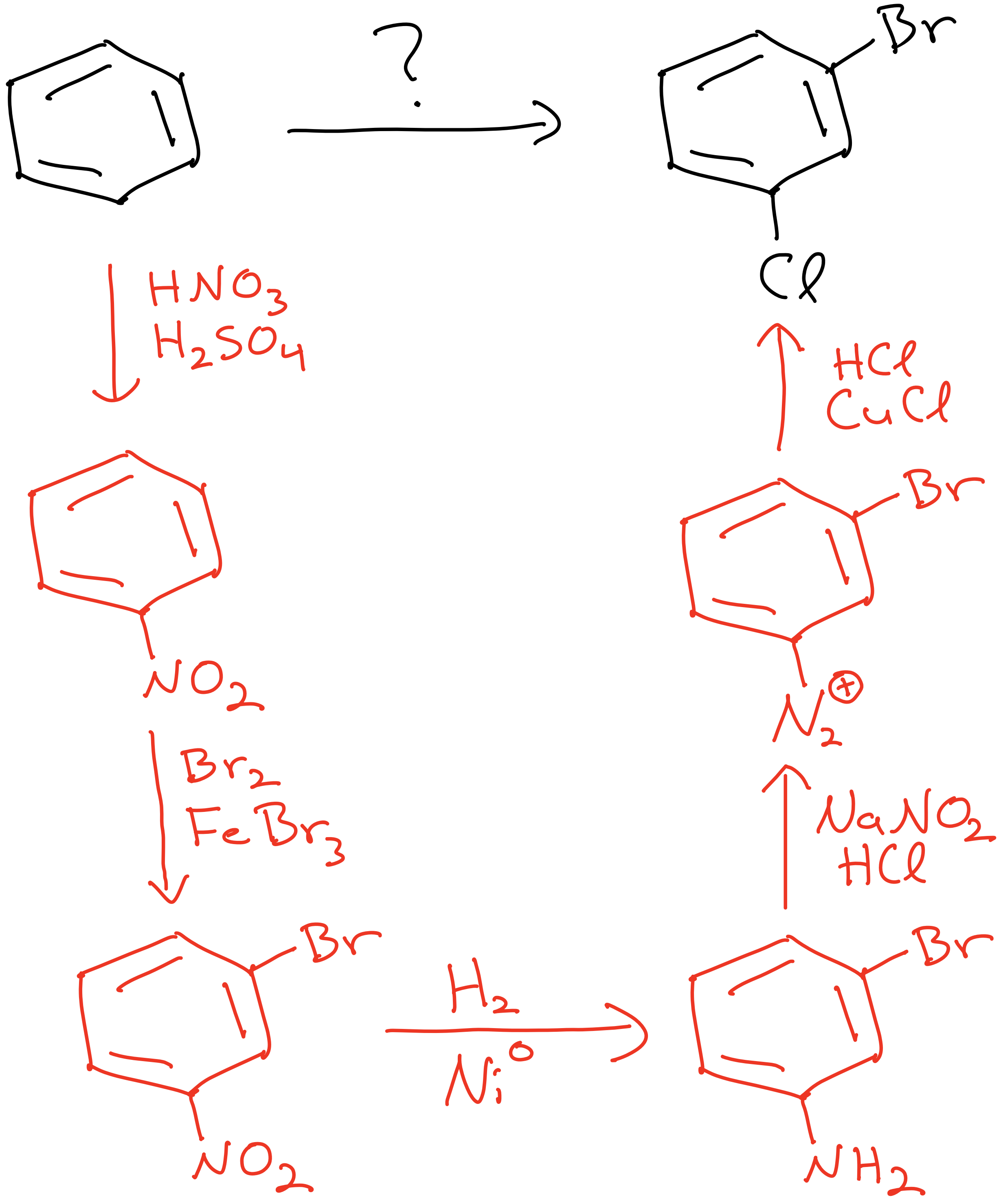
Preparation of Diazoniums, The "Mr. Bill" Reaction



N₂ leaves and is replaced by a variety of reagents → Not responsible for mechanisms

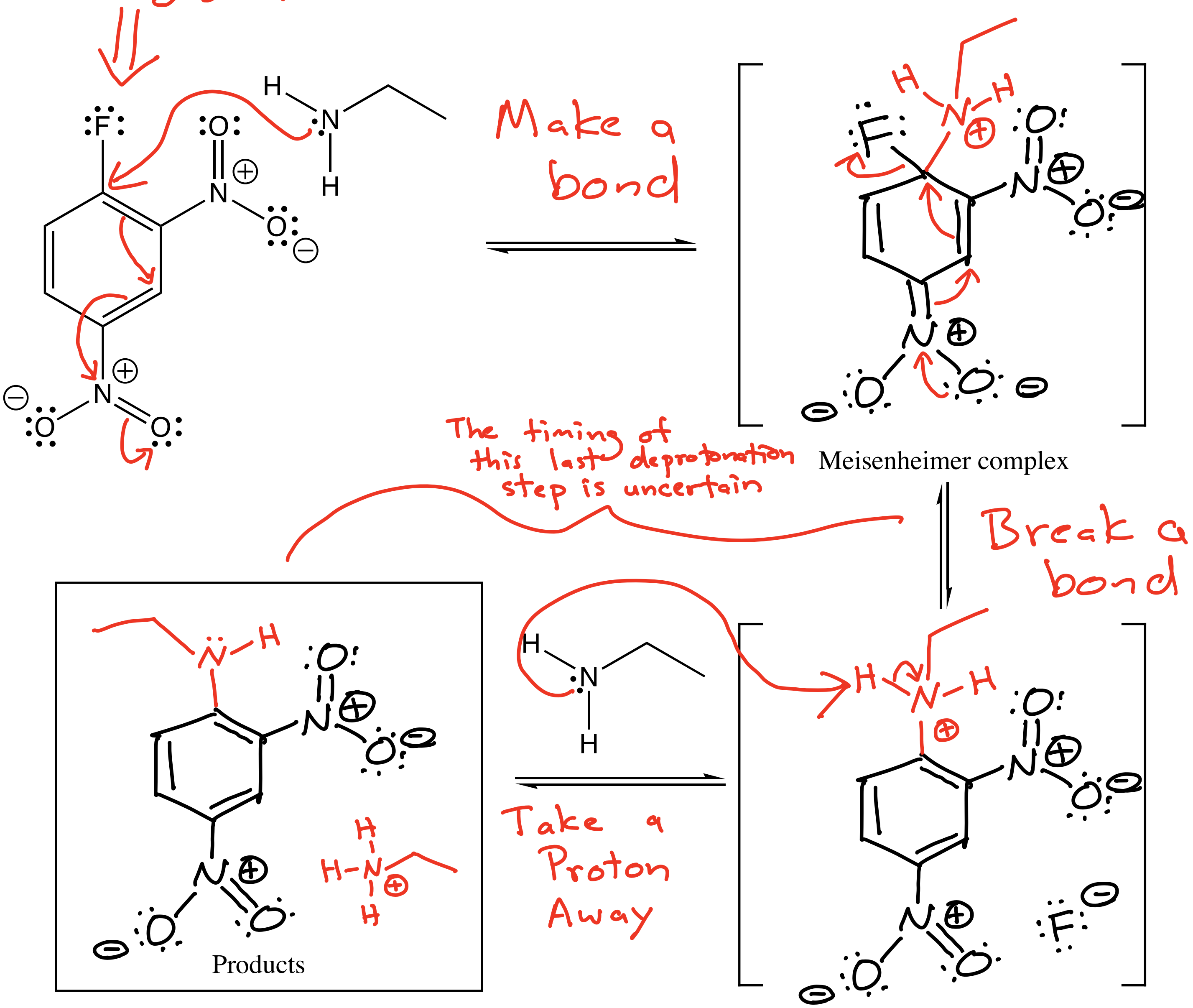

HNO3
H2SO4
BAD
meta directing
NO2
H2
Ni°
New Reaction
NH2
GOOD
ortho, para directing
NaNO2
HCl
N2⊕
Diazonium Salt
H2O
HBF4
HCl
CuCl
HBr
CuBr
KCN
CuCN
KI
H3PO2
OH
F
Cl
Br
CN
I
H
Sandmeyer Reaction
+ N2

How do we carry out the following synthesis?



Nucleophilic Aromatic Substitution

VERY electron deficient aromatic ring because of all the electron withdrawing groups



Make a bond

Meisenheimer complex

Break a bond

The timing of this last deprotonation step is uncertain

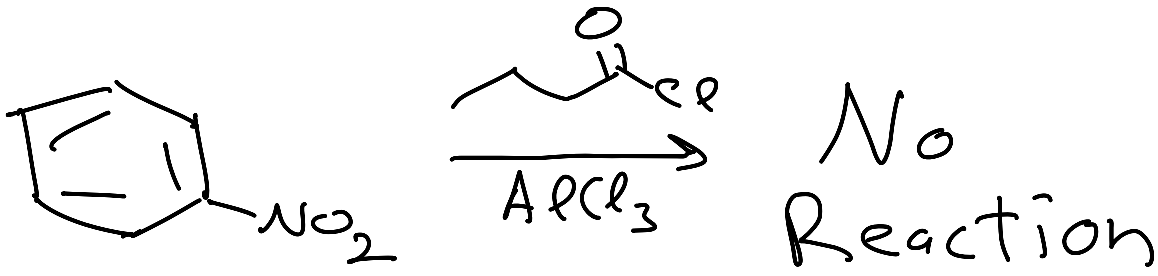
Take a Proton Away

Products

This reaction is relatively rare, and this is the only example you will see in this class

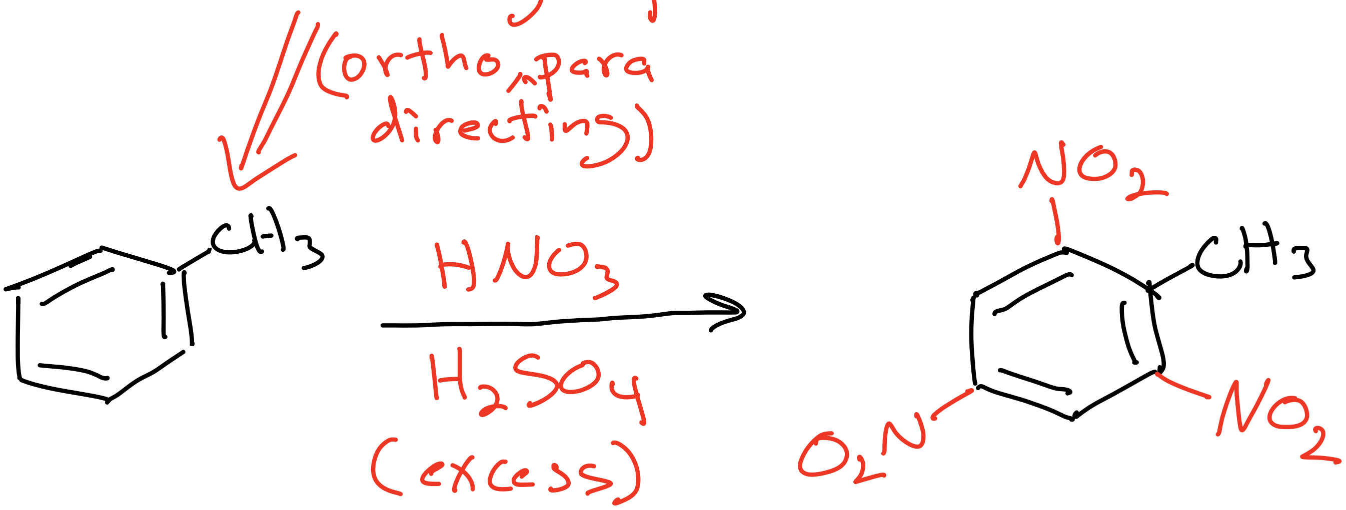
What you need to know about electrophilic aromatic substitution reactions:

1) Friedel-Crafts alkylations and acylations do not work if there is a BAD (i.e. $-NO_2$) group on the ring.



These conditions are not strong enough to overcome a deactivated ring.

However → some reactions with harsh conditions will work:



GOOD group (ortho, para directing)

Toluene

Solvent used in glue for plastic

Trinitrotoluene (TNT)

Boom!

Organic Chemistry is the study of carbon-containing molecules. This class has two points.

The first point of the class is to understand the organic chemistry of living systems. We will teach you how to think about and understand the most amazing molecules on the planet!!

You will learn how MRI scans work. 1/14/26

You will learn the basic principles of pharmaceutical science and how many drugs work. 1/21/26

You will learn about the special bond that holds carbohydrates such as glucose in six-membered rings, connects carbohydrate monomers together to make complex carbohydrate structures and is critical to DNA and RNA structure. 2/2/26

You will learn how soap is made from animal fat and how it works to keep us clean. 2/23/26

You will learn the important structural reason proteins, the most important molecular machines in our bodies, can support the chemistry of life. 2/16/26

You will learn how important antibiotics like penicillins work, including ones that make stable covalent bonds as part of their mode of action. 4/1/26

You will learn why carrots are orange and tomatoes are red. 3/25/26

You will learn the very cool reason that the DNA and RNA bases are entirely flat so they can stack in the double helix structure. 4/8/26

You will learn how energy drinks work.

You will learn even more about why fentanyl is such a devastating part of the opioid problem and how Naloxone is an antidote for a fentanyl overdose.

You will learn even more details about why Magic Johnson is still alive, decades after contracting HIV, and how the same strategy is being used to fight COVID.

You will learn about the surprising chemical reason the Pfizer and Moderna mRNA vaccines elicit strong immune responses.

The second point of organic chemistry is the synthesis of complex molecules from simpler ones by making and breaking specific bonds, especially carbon-carbon bonds.

You will learn how carbon-metal bonds lead to new carbon-carbon bonds. 1/21/26

You will learn how most reactions of carbonyl compounds involve only the four common mechanistic elements operating in only a few common patterns. 1/21/26

You will learn how, by simply adding a catalytic amount of base like HO^- to aldehydes or ketones, you can make new carbon-carbon bonds, giving complicated and useful products. 3/2/26

You will learn a reaction that can convert vinegar and vodka into a common solvent. 2/11/26

CH_3CO_2H CH_3CH_2OH $CH_3\overset{O}{\overset{\|}{C}}-OCH_2CH_3$ (Fischer esterification)

You will learn why molecules with six-membered rings and alternating double bonds are stable. 3/30/26

You will learn a reaction that can turn model airplane glue into a powerful explosive. 4/13/26

Most important, you will develop powerful critical thinking skills:

1. You will learn how to look at a molecule and accurately predict which atoms will react to make new bonds, and which bonds will break during reactions.
2. You will learn how to analyze a complex molecule's structure so that you can predict ways to make it via multiple reactions starting with less complex starting molecules.

Carbohydrates

pentose   hexose

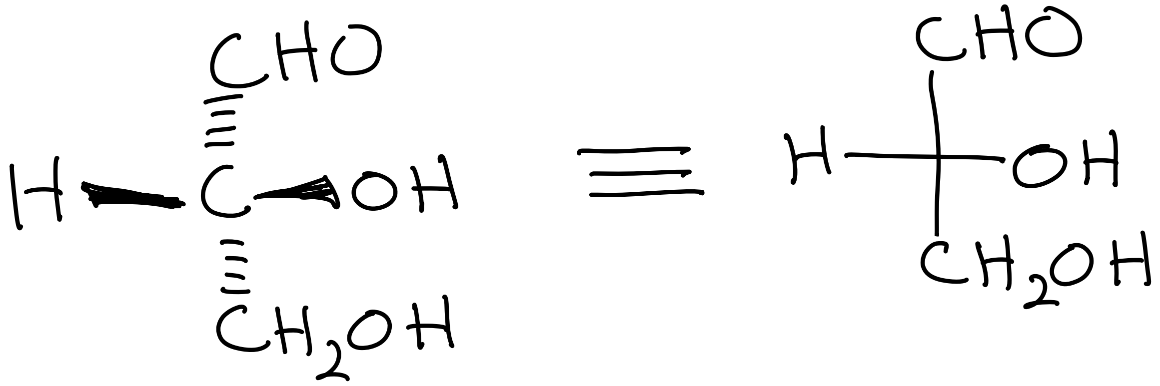
Monosaccharides → 5 or 6 carbons and are aldehydes and ketones

aldose   ketose

Ex.

Glucose is an aldohexose

Stereochemistry



(R)-D-Glyceraldehyde

dextrorotatory
(+)

Called Fischer projection

"Like a Teddy Bear giving you a hug"

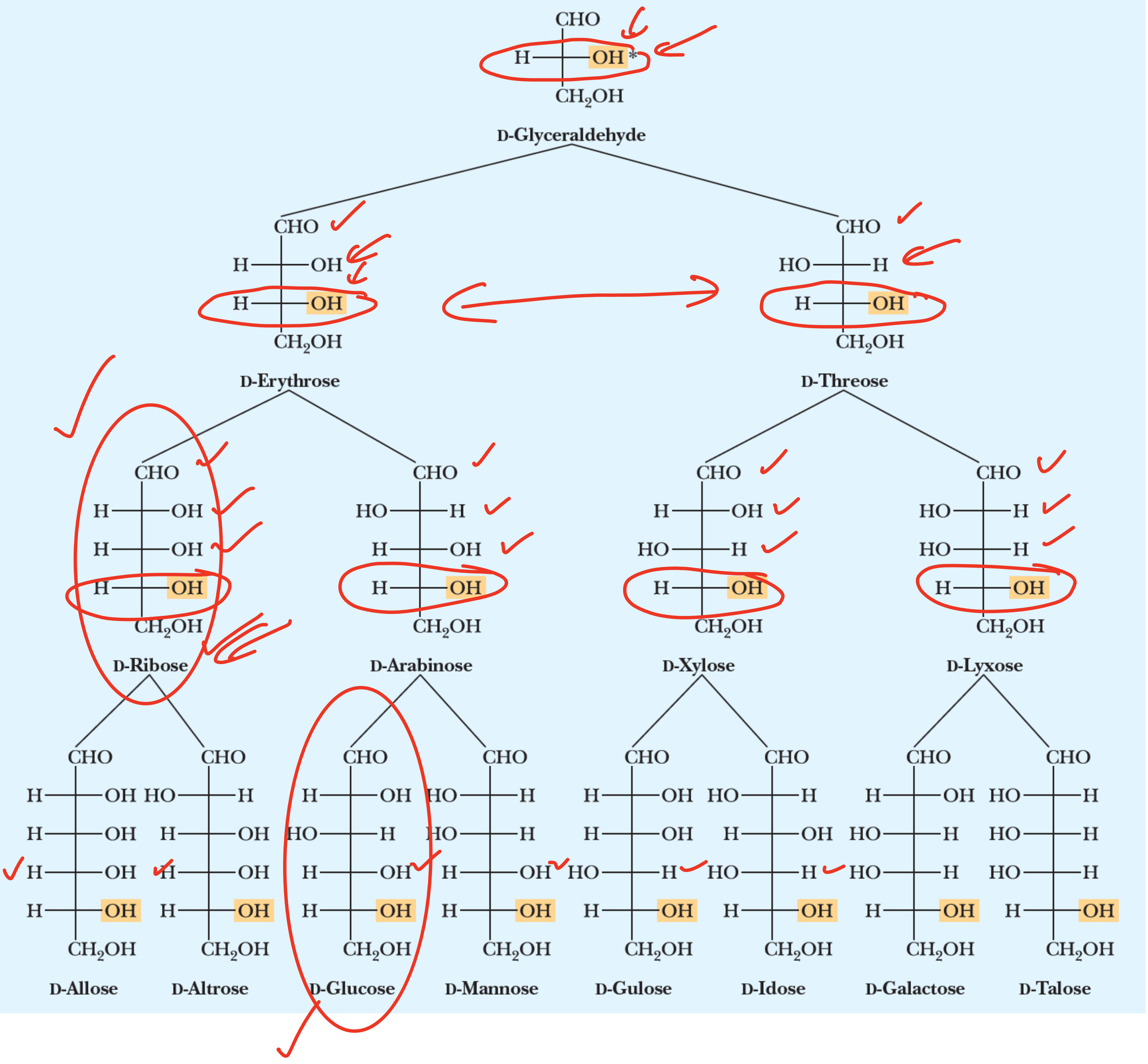

Can I have a hug please?

Stereochemistry defines the different carbohydrates

→ Due to the way carbohydrates are synthesized in cells → the common carbohydrates all have the same stereochemistry as D-glyceraldehyde at the carbon farthest from the carbonyl (aldehyde or ketone)

That is why they are called "D" carbohydrates

Table 25.1 Configurational Relationships Among the Isometric D-Aldotetroses, D-Aldopentoses, and D-Aldohexoses

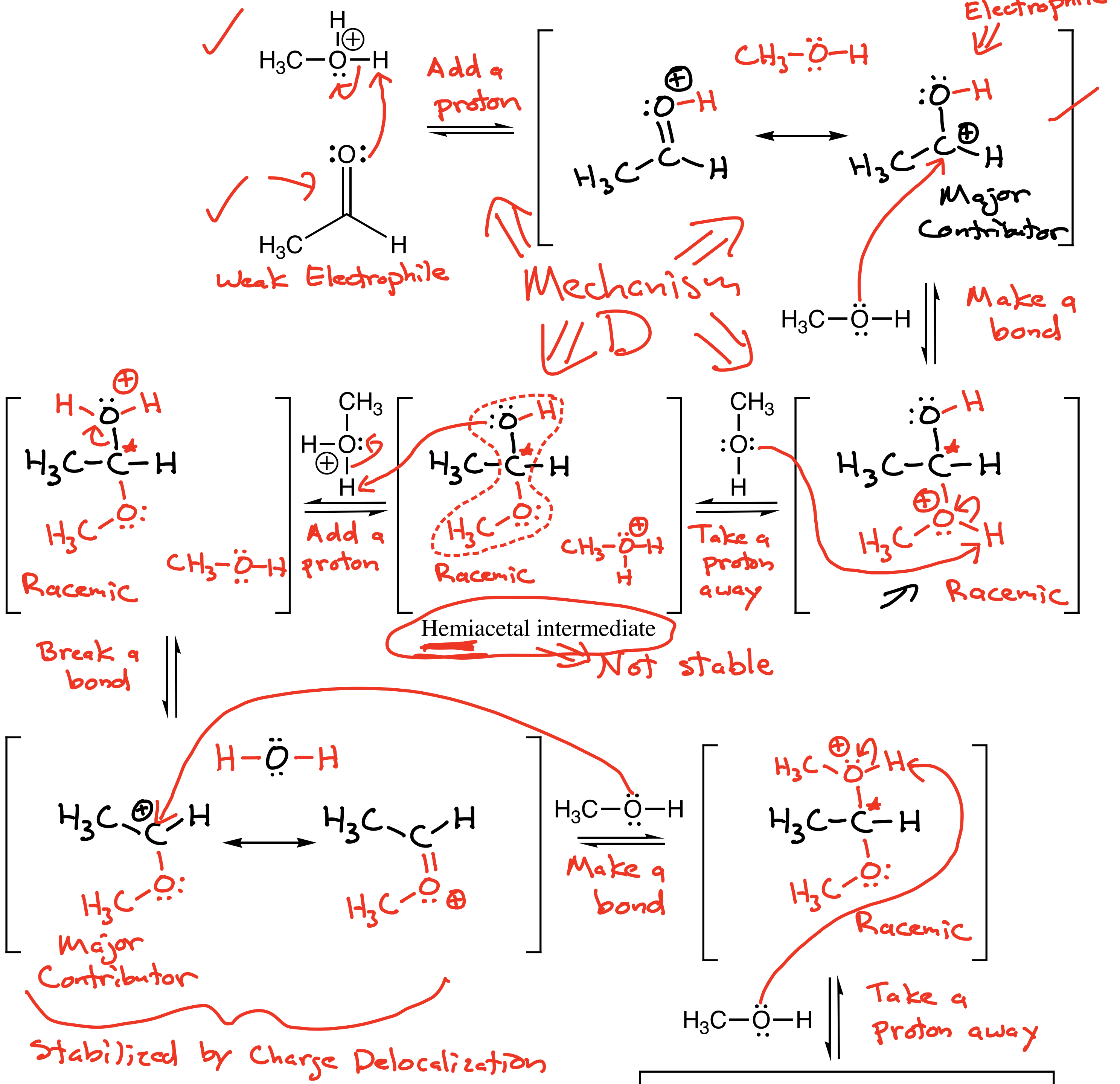



WAYNE'S WORLD

H_2SO_4

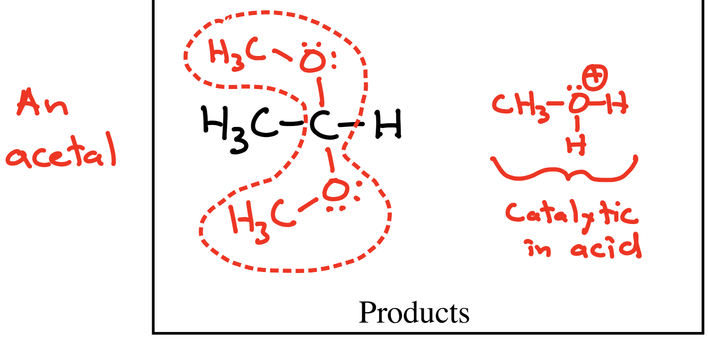
"Hey, does that thing have a hemi in it?" "SWEET!" !

Acid Catalyzed Hemiacetal and Acetal Formation From an Aldehyde or Ketone



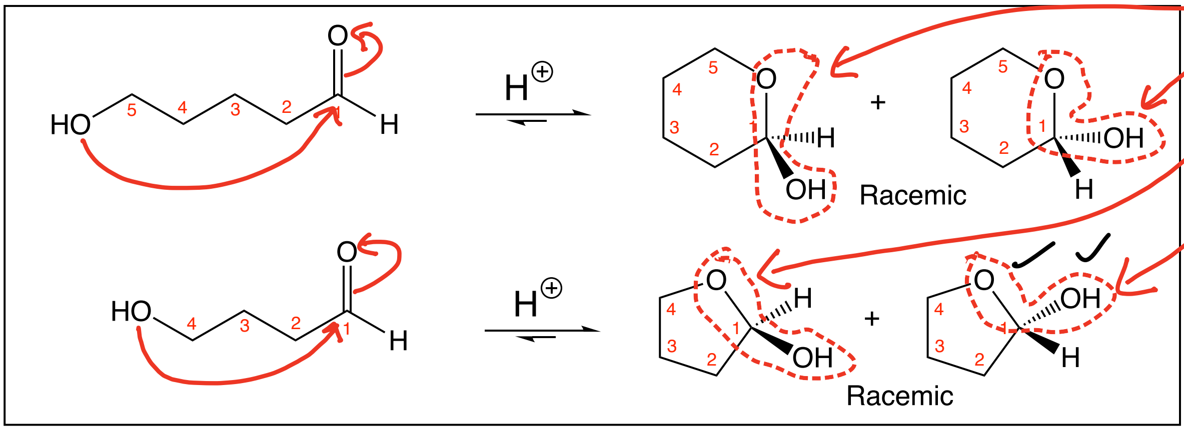
Key Recognition Element (KRE):

Two bonds to O atoms from an sp^3 C atom



Products

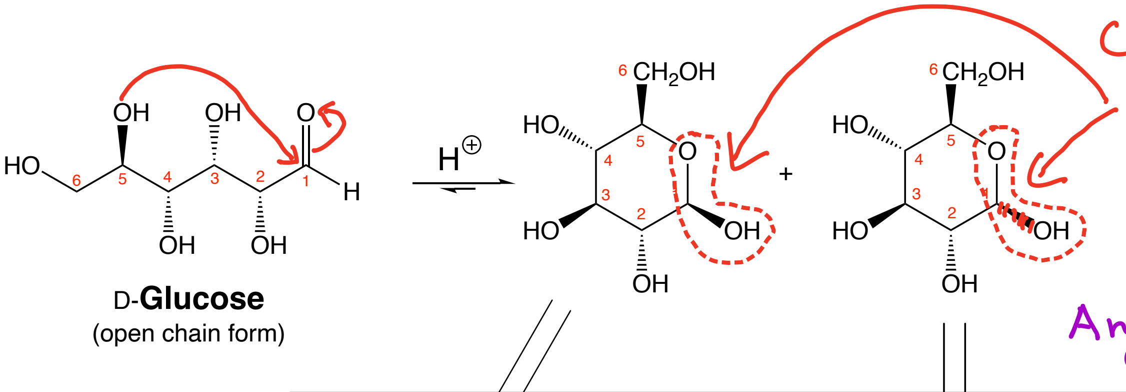
Cyclic Hemiacetals and Carbohydrates



Cyclic hemiacetals

The cyclic form of hemiacetals are stable - "SWEET!"

→ The chelate effect



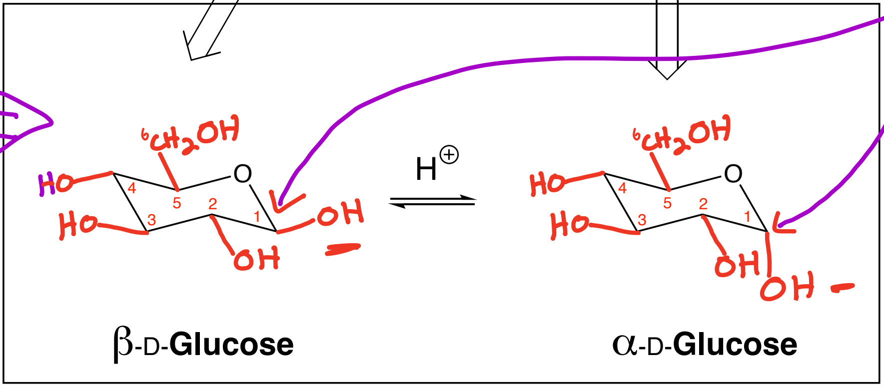
D-Glucose
(open chain form)

Cyclic Hemiacetals

"SWEET!"

Anomeric Carbon

This interconversion is called "mutarotation"



β-D-**Glucose**

α-D-**Glucose**

β-D-Glucopyranose

means "6-mebered ring"

α-D-Glucopyranose

Biochemists call these two forms "anomers"

More stable → every group is equatorial!

Less stable → one -OH is axial

For Glucose: "α is axial!"