CHEM 8A FUNdamentals

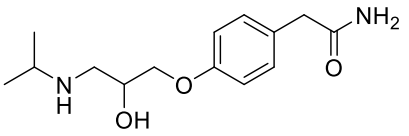
Functional Groups, Arrow-Pushing, Acid-Base Chemistry, Alkene Reaction Review

1. Functional Groups (FGs)

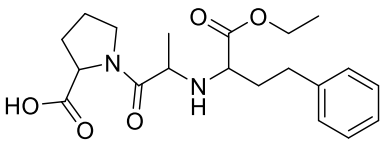
characteristic group of atoms / bonds that possess a predictable chemical behavior

- FGs organize organic molecules by specific bonding patterns – properties & reactivity

*Identify the **FGs** in the blood pressure medications below. **Decode** enalapril (redraw with C's & Hs).*

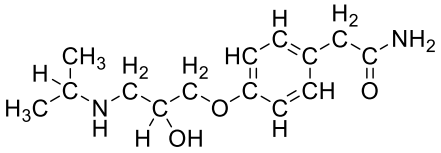


Altenolol



Enalapril

Decoded:



- Be able to identify & draw a simple example of each FG from **Table 2.1**…

TABLE 2.1 EXAMPLES OF COMMON FUNCTIONAL GROUPS

FUNCTIONAL GROUP*	CLASSIFICATION	EXAMPLE	CHAPTER
R—X: (X=Cl, Br, or I)	Alkyl halide	*n*-Propyl chloride	7
C=C	Alkene	1-Butene	7, 8
R—C≡C—R	Alkyne	1-Butyne	9
R—OH	Alcohol	1-Butanol	12
R—O—R	Ether	Diethyl ether	13
R—SH	Thiol	1-Butanethiol	13
R—S—R	Sulfide	Diethyl sulfide	13
	Aromatic (or arene)	Methylbenzene	17, 18
	Ketone	2-Butanone	19
R H	Aldehyde	Butanal	19
	Carboxylic acid	Pentanoic acid	20
	Acyl halide	Acetyl chloride	20
	Anhydride	Acetic anhydride	20
	Ester	Ethyl acetate	20
	Amide	Butanamide	20
	Amine	Diethylamine	22

* The "R" refers to the remainder of the compound, usually carbon and hydrogen atoms.

8A FUNdamentals: Arrow Pushing

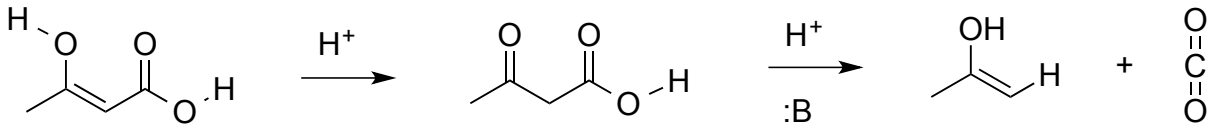
Symbology – all the arrows

Curved	**Fish-hook**	**Resonance**	**Reaction**	**Reversible Reaction**	**Dipole**

** Curved arrows start at Electron Rich (**Nucleophile**) and end at Electron Poor (**Electrophile**)**

Add curved arrows with a note – *which covalent bonds are broken and/or formed according to that arrow?*

B:



Step 1
Bonds broken Bonds formed

Step 2
Bonds broken Bonds formed

Reflect on mistakes: did you have different arrows? Copy your mistakes below and/or your neighbor's mistakes. Discuss what those incorrect arrows mean and why it's incorrect.

8A FUNdamentals: Acid-Base Chemistry

	Bronsted-Lowry Proton (H^+) movement	**Lewis** Electron (e-) movement	$HA \rightarrow H^+ + A^-$
Acids	Donate H^+	**A**ccept **E**lectrons	**Ka**, acid-dissociation constant
Bases	Accept H^+	Donate e-	**pKa** = - log **Ka** **pKa**, affinity of an acid for its proton

Stronger acid

↓ pKa = ↓ affinity for its proton

doesn't need its proton

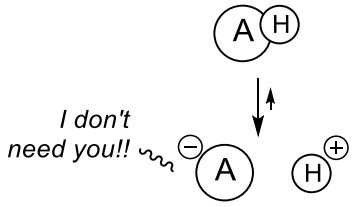
more stable conjugate base

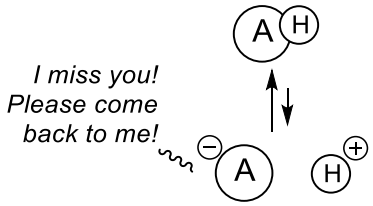
Weaker acid

↑ pKa, ↑ affinity for its proton

needs its proton

less stable conjugate base

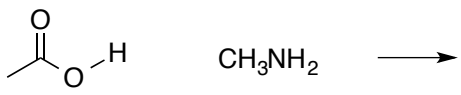




Direction of equilibrium: Who wants that proton (H^+) more??

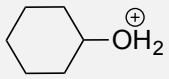
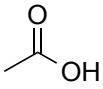
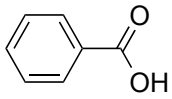
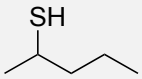
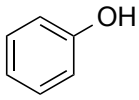
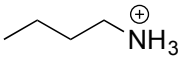
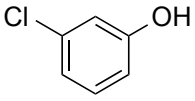
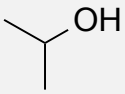
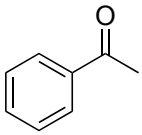
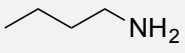
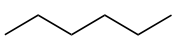
Compare acid (left) to conjugate acid (right)…weaker acid (lower pKa) favored

Draw the arrow-pushing mechanism and products. Then determine the direction of the equilibrium.

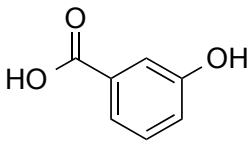


Quantitative Acidity Ranking & the pKa Game!

Find the most acidic H^+ in the molecule and **organize acids by pKa family / FG**

Learn these pKa's with formula, structure, & name			**Functional Group**	**Example of other acid in the pKa family**
pKa	**Formula / Structure**	**Name**		
-7	**HCl**	**Hydrochloric acid**	Inorganic Acids	HBr, H_2SO_4 H_3PO_4, HNO_3
0	**H_3O^+**	**Hydronium**	Protonated Alcohols	
5		**Acetic acid**	Carboxylic Acids	
7	**H_2S**	**Hydrogen sulfide**	Thiols	
10	**$^+NH_4$** **&**  These 2 have same pKa	**Ammonium** **&** **Phenol (PhOH)**	Ammonium derivatives & phenol derivatives	 
16	**H_2O**	**Water**	Alcohols	
19		**Acetone**	Carbonyls: ketone, aldehyde, ester, amide, anhydride, acid halides	
35	**NH_3**	**Ammonia**	Amines	
50	**CH_4**	**Methane**	Hydrocarbons	

What if there's more than one functional group?!



<u>Qualitative Acid Ranking</u>: ARIO = atom, resonance, induction, orbitals

ATOM: which atom bears the charge better?

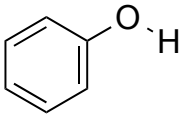
Refer to periodic table of elements

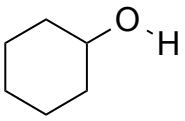
- <u>Same row</u> – more electronegative atom vs. <u>Same column</u> – larger atom

Ex. Any **thiol** is more acidic than any **alcohol**

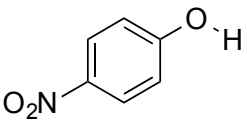
RESONANCE: can the negative charge be spread out by resonance?

Any phenol is more acidic than any alcohol

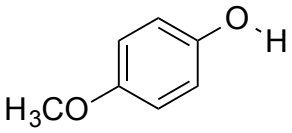




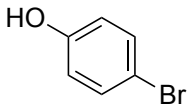
- <u>Electron withdrawing groups (EWG's)</u> increase acidity decrease acidity

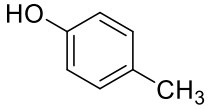


- <u>Electron donating groups (EDG's)</u>



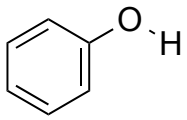
INDUCTION: are electronegative atoms nearby to stabilize the charge?

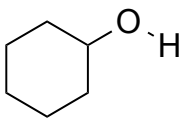




ORBITAL: Electrons held farther from nucleus are less stable than those held closer

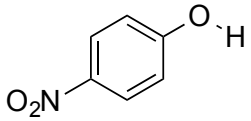
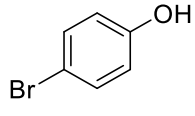
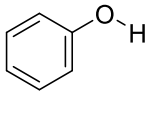
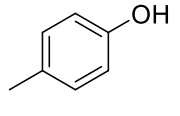
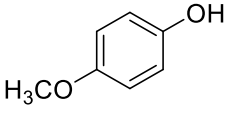
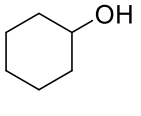
- sp^2 atoms are happier with negative charge than sp^3 atoms.





MOST ACIDIC **LEAST ACIDIC**

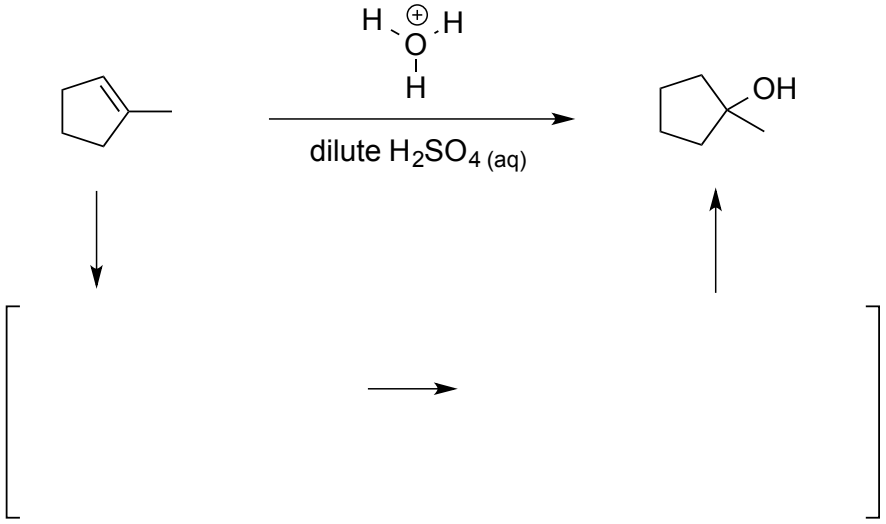
(lower pKa) (higher pKa)

8A FUNdamentals: Preparation of Alcohols from Alkenes (Chapter 8)

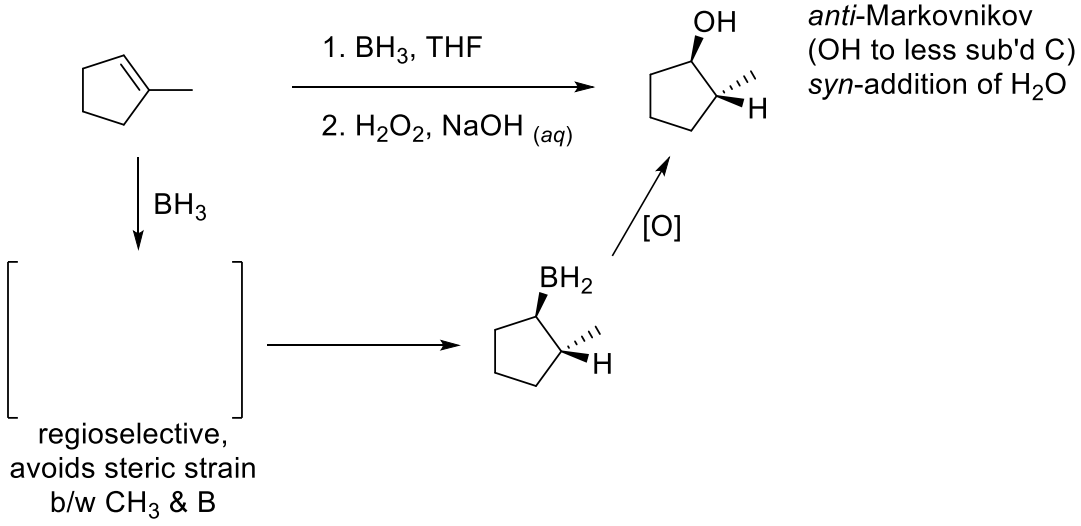
Any reactions & mechanisms from CHEM 8A that you need to know will be reviewed in 8B, starting with…

Acid-Catalyzed Hydration – Markovnikov Addition of Water

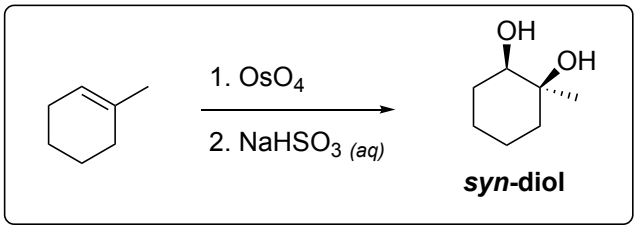


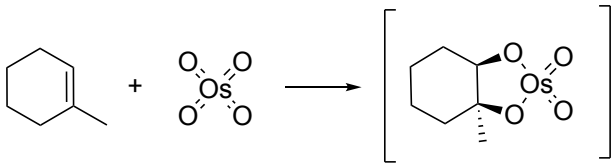
Hydroboration / Oxidation – *anti*-Markovnikov addition of water

- H & OH added *syn*; OH goes to less substituted alkene carbon

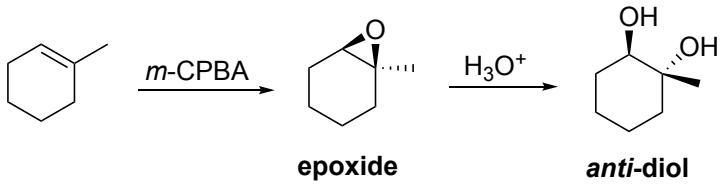


***cis*-Hydroxylation**

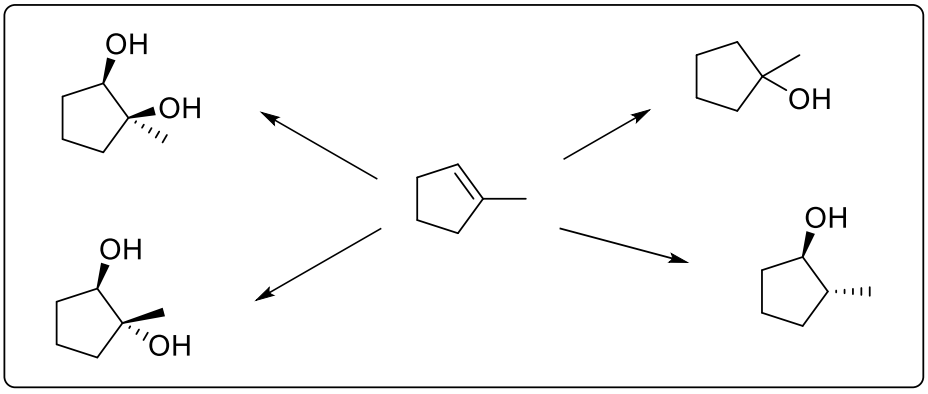




Epoxidation & Epoxide-Opening



Alcohol preparation summary:



END-O-CLASS SUMMARY: CHEM 8A Review & A Lil bit of Chapter 12

Functional Groups, Arrow-Pushing, Acid-Base Chemistry, Alcohol Preparation Review