

## CHEM 120 Content Outline and Workshops

### I. Bonding (Chap 4/3)

- A. Periodic trends
- B. Valence electrons
- C. Ionic vs. covalent bonding
- D. Lewis  $e^-$  dot formulas (4.7)
- E. Sigma vs. pi bonds  
(not in textbook)
- F. VSEPR (4.8)
- G. Formal charges  
(not in textbook)

### Workshop 1: covalent (ionic) bonds

### II. Drawing Structures (C12 etc.)

- A. Molecular Formulae
- B. Condensed structures
- C. Expanded structures
- D. Line structures
- E. Mixed structures
- F. Conformational possibilities
  - 1. Single bonds rotate
    - a. Newman projections
  - 2. Double bonds fixed
- G. Ring Structures
  - 1. Non-aromatic
  - 2. Aromatic
- H. Isomers
  - 1. Rotamers
    - i. Newman projections
  - 2. Structural
  - 3. Chirality/enantiomers
  - 4. cis/trans (*E/Z*)
  - 5. Diastereomers
    - i. Fischer projections

### WS 3: Isomer? Rotamer? etc.

### III. Functional Groups (12.2)

(*italics* = not in 12.2)

- A. Saturated functional groups
  - 1. Alkanes
  - 2. Alkyl halides
  - 3. Alcohols  
*1°*, *2°*, *3°*
  - 4. *Phenols*
  - 5. Ethers/sulfides
  - 6. Thiols
  - 6. Disulfides
  - 8. Amines  
*1°*, *2°*, *3°*, *4°*, *anilines*
- B. Unsaturated FGs
  - 1. Alkenes
  - 2. Alkynes
  - 3. Aromatic rings (6  $e^-$ s)
    - a. 6-member rings
    - b. 5-member rings
    - c. *Heterocycles*
  - 4. Aldehydes/ketones

- 5. Carb. acids/*anhydrides*
- 6. Esters
- 7. Amides
- 8. *Ureas/guanidines*

### WS 2: Recognizing common FGs

- C. Phosphate esters/anh. (17.6)
- D. Polymers (CiA p 121)
  - 1. Monomers
  - 2. Addition pol. (13.7)
  - 3. Condensation pol. (17.5)
  - 4. Recycling (Symbols 1-6)

### IV. IM forces/Coulombs Law (8.2)

(Greatly expanded from TB)

- A. LDF/induced dipoles
- B. Polarizability and pi bonds
- C. Dipole-dipole
- D. Hydrogen bonds
  - 1. H-bond donors
  - 2. H-bond acceptors
- E. Ions
- F. Mixed IM Forces
- G. BP effects  
(largely not in textbook)  
rank BP of FGs and give basis
- H. Solubility in Water  
(largely not in textbook)  
any H-bond gives solubility
- I. Branching & BP/sol.  
(not in textbook)
- K. H-bond vs. dipoles  
overlap in strength

### WS 6: BP/water sol. trends

### V. Acid and Bases (Chap 10)

(Brønsted only)

- A. Conjugate acids and bases
- B. pH (10.5),  $K_a$  (10.3), &  $pK_a$   
(mostly qualitative)  
( $pK_a$  not in textbook)
- C. Strong acids- $H_3O^+$  (10.2)
- D. Phosphoric acid (buffer etc)
- E. Strong base- $HO^-$  (Table 10.2)
- F. Carbonic acid/bicarbonate
- G. Conjugates base stability
  - 1. Periodic trends
    - a. HI, HBr, HCl, HF
    - b.  $NH_3$ ,  $H_2O$ , HF
  - 2. Induction,  $HOCl$
  - 3. Resonance,  $H_2SO_4$

### WS 4: Acid/base fundamentals

- F. Organic acids
  - 1. Carboxylic acids  
(10.2/17.2)
  - 2. Phenols (14.6) & thiols  
(thiol acidity not in TB)

### G. Organic Bases

- 1. Amines (16.5)
- 2. Heterocycles  
(Het. basicity not in TB)
  - a. Pyridine
  - b. Pyrimidine
  - c. Pyrrole
  - d. Purine
  - e. Imidazole
  - f. Indole

### H. Extractions

(not in textbook)

- I. Buffers (qualitative) (10.10)
- J. Physiological protonation

### WS 10: Acids, bases, and solubility

### VI. Nomenclature (12.6 etc.)

#### A. IUPAC

- 1. Alkanes, halides, ethers
- 2. Radical names
  - a. Systematic
  - b. Traditional  
isopropyl  
isobutyl  
sec-butyl  
tert-butyl  
phenyl  
vinyl
- 3. Benzene derivatives
  - a. Ortho/met/para
  - b. Numbering
  - c. Common cores
    - i. Toluene
    - ii. Phenol
    - iii. Aniline
    - iv. Benzoic acid
    - v. Styrene

#### 4. FG-based naming

- a. Alcohols
- b. Amines
- c. Aldehydes/Ketones
- d. Carboxylic acids
- e. Esters
- e. Amides

#### 5. FG priorities

#### B. Common Names

(some not in textbook)

- 1. Alcohols
- 2. Amines
- 3. Ethers
- 4. Aldehydes
  - a. formaldehyde
  - b. acetaldehyde
  - c. benzaldehyde
- 5. Ketones

- a. Acetone
  - b. Acetophenone
  - c. diphenyl ketone etc.
5. C. acids
- a. Formic acid
  - b. Acetic acid
  - c. Propionic acid
  - d. Butyric acid
  - e. alpha, beta, etc
  - f. Stearic acid  
(surfactants)
  - g. Succinic acid
  - h. Oxalic acid
  - i. Phthalic acid

- C. Polyfunctional compounds
1. Diol, dione, etc.
  2. use of "oxo-"
  3. FG priorities

**WS 5: Common/IUPAC names**

**VII. Thermo/Kinetics** (Chap 7)

- A. Enthalpy
- B. Entropy (7.4)
- C. Gibbs free energy (7.4)
- D. Equilibrium
- E. Kinetics and  $E_a$
- F. Energy Diagrams (7.5)
- G. Catalysts (7.6)
- H. Mechanism example,  $H_2/Pt$

**VIII. Chem. Transform** (13.5 etc)

- A. Free radical rxns (12.8)
  1.  $O_2$  rxns
  2. Halogenation of RH
- B. Substitution rxns (broad def.)
  1. C. acid derivatives (C 17)
    - a. Acid/ester
      - i. Fischer est.
      - ii.  $H^+$  or  $OH^-$  hyd.
    - b. Acid/amide
      - i. thermal
      - ii. via anhydride
      - iii.  $H^+$  or  $OH^-$  hyd.
  2. Acetal (15.7)
  3. Ald. to acid oxid. (15.5)
    - a. Chromic acid
    - b.  $Ag^+$  (Tollens')
    - c.  $Cu^{2+}$  (Benedict's)
  4. Thiol oxid./red. (14.8)
  5. Phosphate esters /anh.  
(conceptual only)
- C. Addition rxns
  1. To  $C=C$  (13.6)
    - a. Halogens
    - b. Water (Markovnikov)
    - c. HX
    - d.  $H_2$  (reduction)
      - i. w/ $Pt, Pd, Ni$
  2. To  $C=O$  (ald/ket)

- a. Hydrates
- b. Hemiacetals (15.7)
  - i. ROH nucleophile
  - ii. electronic effects
  - iii. entropy
- c.  $H_2$  (red.) (15.6)
  - i. w/ $Pt, Pd, Ni$
  - ii. w/ $NaBH_4$

- D. Elimination rxns
1. To make  $C=C$  (14.4)
    - a. From ROH (Saytzeff)
  2. To make  $C=O$ 
    - a. From hemiacetal
    - b. Oxid. alcohol (15.7)
      - i. Chromic acid/ket.
      - ii. ~~PCC~~ WATER/ald.
- E. Rearrangement  
(Cf keto/enol in 22.3)

**WS 7: Orgo reaction patterns**

**IX. Biological molecules**

- A. Lipids (Chap 23)
  1. Fatty acids
    - a. Length
    - b. Unsaturation
      - i. cis normal
      - ii. delta location
      - iii. MP effects
    - c. Omega designation
  - d. Examples
    - Steric acid
    - Oleic acid
    - Arachidonic acid
  - e. Melting point
  - f. Fatty esters
- 2. Eicosanoids
  - a. Prostaglandins
  - b. Leukotrienes
- 3. Triglycerides
  - a. Contain glycerin
  - b. Partial hydrogenation
  - c. Biodiesel
- 4. Phospholipids
  - a. Glycerolipids
    - i. of Serine
    - ii. of Ethanol amine
    - iii. of Choline
    - iv. of Inositol
  - b. Sphingomyelins
    - i. w/phosphocholine
    - ii. w/ glucose/gal.
  - c. Polar head groups
  - d. Glycolipids
    - i. of Sphingosine
    - ii. Blood types
- 5. Steroids
  - a. Cholesterol
  - i. HDL

- ii. LDL
- iii. Esters
- b. Bile salts
- c. Sex hormones
  - i. Testosterone
  - ii. Estradiol
- d. Glucocorticoids
  - i. Cortisol/Stress

6. Terpenes
7. Micelles/cell membranes
- a. Diffusion
  - b. Passive transport
  - c. Active transport
  - d. Cell signaling

8. Fat digestion

**WS 11: Know your lipids**

- B. Carbohydrates (Chap 20)
  1. Aldohexoses
    - a. Glucose
    - b. Galactose
    - c. Glyceraldehyde
  2. Aldopentoses
    - a. Ribose
    - b. Deoxyribose
  3. Ketohexoses
    - a. Fructose
    - b. Dihydroxyacetone
  4. Aldose/Ketose isomeriz.
  5. Alditols (sorbitol)
  6. D vs. L sugars
  7. Anomeric center
  8. Haworth structures
  9. Equilibrium forms
    - a. Pyranoses
    - b. Furanoses
  10. Disaccharides
    - a. Sucrose
    - b. Lactose
    - c. Maltose
  11. Polysaccharides
    - a. Glycogen
    - b. Starch
      - i. Amylose
      - ii. Amylopectin
    - c. Cellulose
  12. Nomenclature (simple)
    - a. Alpha vs. beta
    - b. Point of attachment
  13. Reducing sugars
    - a. hemiacetal/aldehyde
    - b. ketose to aldose
  14. Biological functions

**WS 12: Know your carbs**

- C. Amino acids/pept. (Chap 18)
  1. Classification of AAs  
(Not all same as textbook)  
(Know 3-letter abbr.)

- a. Lipophilic
  - Alanine
  - Valine
  - Leucine
  - Isoleucine
  - Methionine
  - Phenylalanine
  - Tryptophan
- b. Hydrophilic
  - Serine
  - Threonine
  - Asparagine
  - Glutamine
  - Tyrosine
- c. Acidic (hydrophilic)
  - Aspartic acid
  - Glutamic Acid
- d. Basic
  - Lysine
  - Histidine (weakly)
  - Arginine (strongly)
- e. Aromatic
  - Phenylalanine
  - Tyrosine
  - Tryptophan
  - Histidine
- f. Special
  - Glycine
  - Proline
  - Cysteine
- g. Modified/non-coded
  - hydroxyproline
  - hydroxylysine
- 2. Primary structure-amides
  - a. Peptide names
- 3. Secondary structure
  - a. Alpha helix
  - b. beta sheets
  - c. Triple helix/collagen
  - d. Supersecondary str
    - i. Beta turn
- 4. Tertiary structure
  - a. "Orgo" IM forces
  - b. Salt bridges
  - c. Disulfides
- 5. Quaternary structure
  - a. Hemoglobin
  - b. Insulin
  - c. Fe storage protein
- 6. Protein flexibility
- 7. Protein syn. and process. (conceptual)
- 8. Ionization at pH 11/7/1
- 9. pI (peptides, not aa's)
- 10. Protein flexibility
  - a. FA transport protein
- 11. Types of proteins

- a. structural
  - collagen
- b contractile
  - myosin/actin
- c. transport
  - HSA
- d. enzymes
- e. protective
  - antibodies
- f. storage
  - ferritin
- g. hormones
  - insulin
- h. other
  - receptors
  - ribosomal channels
- 11. Protein denaturation
- 12. Protein hydrolysis
  - a. Specific proteases
    - thrombin
  - b. Promiscuous prot.
    - trypsin
- WS 8: Know your amino acids**
- D. Enzymes (Chap 19)
  - 1. Biocatalysts, not magic
  - 2. High selectivity possible
  - 3. -ES-react-EP-
    - a. Induced fit
    - b. Lock and Key
    - c. Range of possibilities
  - 4. Cofactors
    - a. Metals
      - Mg<sup>2+</sup>, Zn<sup>2+</sup>, Fe<sup>2/3+</sup>
    - b. Coenzymes (no structures)
      - CoA
      - SAM
      - NAD/FAD
      - ATP
  - 5. Regulation
    - a. Expression
    - b. Proenz./zymogens
    - c. Inhibitors
      - i. Competitive
      - ii. Non-competitive
      - iii. Irreversible
    - d. Activators
    - e. Kinase/Phosphatase
- 6. Reaction Types
  - a. Oxidoreductases
  - b. Transferases
  - c. Hydrolases
  - d. Lyases
  - e. Isomerases
  - f. Ligases
- 7. Mechanism example

- b. Chymotrypsin
- 8. Coupled reactions
  - a. Sequential
  - b. Simultaneous
- WS 9: Know your enzymes**
- E. Glycolysis (Chap 22) (metabolism, anabolism, catabolism, digestion)
  - 1. Glu to G6P-hexokinase
    - a. Irreversible
    - b. ATP used
    - c. Product inhibited
  - 2. to F6P-phos glu isomer.
  - 3. to FBP-phos fruc kinase
    - a. Irreversible
    - b. Committed
    - c. ATP used
    - d. Highly regulated
  - 4. to DAP/GAP-aldolase
  - 5. to GAP-trioseP isomer.
  - 6. to GBP-Gly 3P DeH<sub>2</sub>ase
    - a. NAD<sup>+</sup> to NADH
  - 7. to PG3-P glycerate kinase
    - a. ATP made
  - 8. to PG2-P glyc. mutase
  - 9. to PEP-enolase
  - 10. to Pyr-pyruvate kinase
    - a. Irreversible
    - b. ATP made
  - 11. to AcCoA-pyr. deH<sub>2</sub>ase
    - a. In mitochondria
    - b. NADH made
  - 12. to Citric acid cycle
  - 13. to fatty acid syn.
- WS 13: Know glycolysis**
- F. Biological amines
  - 1. Acetylcholine
  - 2. Serotonin
  - 3. Catecholamines
    - a. Dopamine
    - b. Norepinephrine
    - c. epinephrine
      - aka adrenaline
  - 4. Histamine
  - 5. Glutamate
  - 6. GABA
- G. DNA and RNA (Chap 26, only some basics)
  - 1. DNA Base pairs
    - a. Adenine-Thymine/AT
    - b. Guanine-Cytosine/GC
    - c. Free base
    - d. Nucleoside
    - e. Nucleotide
  - 2. Double helix
    - a. A, B and Z forms
    - b. Major/minor grooves

- c. Variable flexibility
- 2. RNA
  - a. GC and AU (Uracil)
  - b. Different types
    - i. Messenger
    - ii. Transfer
    - iii. Ribosomal
  - c. Structured
- 3. Key functions
  - a. Replication of DNA
  - b. Transcription to RNA
    - i. editing required
  - c. Translation to protein
  - d. PT modifications
- 4. Anti-cancer drugs  
(not in TB, mostly appreciation)
  - a. DNA alkylation
    - i. N7 of guanine
    - ii. Cross-linked DNA
    - iii. abasic sites
    - iii. Chlorambucil
    - iv. cis-Platin
  - b. Intercalation
    - i. Flat/aromatic
    - ii. Doxorubicin
  - c. Minor groove binders
    - i. Anthramycin
  - d. Major groove binders
    - i. very uncommon
    - ii. DNA regulation
    - ii. Actinomycin D
  - e. 2ary interactions
    - i. ionic
    - ii. entropy
  - f. Antimetabolites
    - i. 5FU
    - ii. Methotrexate
    - iii. Thymidylate Syn

**X. The scientific method and scientific models**

- A. VSEPR
- B. Hybrid orbitals  
(methane only)
- C. Molecular orbitals (O<sub>2</sub>)  
(appreciation only)

**XI. Medicinal Chemistry**

for appreciation only

- A. Calicheamicin
- B. Insulin
- C. Estradiol/Evista
- D. Opioids
- E. Amphotericin  
(micafungin)
- F. Bevacizumab/Avastin (MoAb)
- G. Activase (tPA)
- H. Lipitor/Statins
- I. Fomivirsen/Vitravene

WS 1	1	Tues, Aug 29	Introduction	What is Orgo and How to survive it
	2	Thurs, Aug 31	Chapter 12	Bonding/hydrocarbons/functional groups
WS 2	3	Tues, Sept 5	Chapter 10	Acids and Bases
	4	Thurs, Sept 7	Chapter 13	Alkenes, Alkynes, and Aromatic Compounds
WS 3	5	Tues, Sept 12		
	6	Thurs, Sept 14	Chapter 14	Alcohols, Phenols, Thiols, Ethers, Chirality
	7	<b>Tues, Sept 19</b>	<b>EXAM 1: Chapters 10, 12-13</b>	
WS 4	8	Tues, Sept 26	Chapter 14 (cont.)	Alcohols, Phenols, Thiols, Ethers
	9	Thurs, Sept 28	Chapter 16	Amines
WS 5	10	Tues, Oct 3	Chapter 15	Aldehydes and Ketones
	11	Thurs, Oct 5		
WS 6	12	Tues, Oct 10	Chapter 17	Carboxylic Acids and Their Derivatives
	13	Thurs, Oct 12		
WS 7	14	<b>Tues, Oct 17</b>	<b>EXAM 2: Chapter 10, 12-16, but emphasis on Chapters 14 - 17</b>	
	15	Thurs, Oct 19	Chapter 18	Amino Acids and Proteins
WS 8	16	Tues, Oct 24		
	17	Thurs, Oct 26	Chapter 7	Kinetics and Thermodynamics
WS 9	18	Tues, Oct 31	Chapter 19	Enzymes and Vitamins
	19	Thurs, Nov 2		
WS 10	20	<b>Tues, Nov 7</b>	<b>EXAM 3: Chapters 7, 10, 14-19, but emphasis on Chapters 7, 18-19</b>	
	21	Thurs, Nov 9	Chapter 23/24	Lipids
WS 11	22	Tues, Nov 14		
	23	Thurs, Nov 16	Chapter 20	Carbohydrates
WS 12	24	Tues, Nov 28		
	25	Thurs, Nov 30	Chapter 21/22	Glycolysis & Gluconeogenesis
WS 13	26	Tues, Dec 5		
	27	<b>Thurs, Dec 7</b>	<b>EXAM 4: Chapters 7, 10, 14-24, but emphasis on Chapters 20-24</b>	
WS 14	28	Tues, Dec 12	Chapter 26 (added material)	DNA and DNA Anticancer Drugs
	29	<b>Thurs, Dec 14, 6:20-8:20 PM-COMPREHENSIVE FINAL EXAM, emphasis on major themes</b>		

WS #1: Covalent (ionic) bonding

WS #2: Recognizing common FG's

WS #3: Isomer? Rotamer? etc.

WS #4: Acid/base fundamentals

WS #5: Common/IUPAC names

WS #6: BP/water sol. trends

WS #7: Orgo reaction patterns

WS #8: Know your amino acids

WS #9: Know your enzymes

WS #10: Acids, bases, and solubility

WS #11: Know your lipids

WS #12: Knows your carbs

WS #13: Know glycolysis

WS #14: Semester Review