

# CHEMISTRY 260 EXAM 1 OBJECTIVES

## Chapter 1 – Biochemistry: Setting the Stage

terminology:	eukaryotes	prokaryotes	organelles
supramolecular assemblies	cell membranes	ribosomes	cytoplasm
nucleus	mitochondria	enzymes	amino acids
proteins	carbohydrates	monosaccharides	polysaccharides
nucleotides	nucleic acids	ATP	DNA
RNA	lipids	fatty acids (saturated, unsaturated)	glycerol
hydrolysis	condensation	homopolymers	heteropolymers

### Objectives:

- 1) Know the differences between prokaryotes and eukaryotes and the general components (of those listed above) in each type of cell. Know which types of biomolecules make up these cell components. Know the main functions of these cell components.
- 2) Know the biomolecular elements that are found in large quantities and are essential for life.
- 3) Know these organic functional groups: alcohol, aldehyde, ketone, carboxylic acid, amine, pyranose ring, furanose ring, purine ring, pyrimidine ring, amide, ester, phosphoester, and phosphoanhydride.
- 4) Know which of these functional groups are commonly found in monosaccharides, amino acids, fatty acids and nucleotides.
- 5) Know which of these functional groups combine to give the biopolymers of carbohydrates, proteins, lipids and nucleic acids.
- 6) Be able to **draw structures**, or **give names**, of the **product molecules** from condensation or hydrolysis reactions given the reactants or reacting functional groups.

## Chapter 2 – The Flow of Biological Information

genome	genes	complementary base pairs	replication
DNA polymerase	template	transcription	RNA polymerase
ribosomal RNA	messenger RNA	transfer RNA	translation
genetic code	amino acid-tRNA synthetase	introns	exons

### Objectives:

- 1) Understand the abbreviations for nucleotides. Know how to indicate nucleic acid base sequence. Understand the sequence direction of complementary nucleic acid strands.
- 2) Know the functions of rRNA, mRNA and tRNA.

- 3) Understand the structural relationships (complementary base pairs, sequence direction, genetic code) between DNA, mRNA and the amino acid sequence of proteins.

### Chapter 3 – Biomolecules in Water

terminology:	ionic forces	noncovalent interactions	van der Waals forces
polar, hydrophilic	nonpolar, hydrophobic	hydrogen bonding	molecular recognition
amphiphilic	$K_{\text{water}}$	pH	$K_a$
$pK_a$	conjugate acid-base pair	weak acid (weak base)	buffer system

#### Objectives:

- 1) Know which noncovalent interactions are important for the functional groups listed from chapter 1.
- 2) Be able to do the calculation to convert between pH and  $[H^+]$ ;  $pK_a$  and  $K_a$ .
- 3) Given the  $pK_a$  of a conjugate acid-base pair and the pH of its' solution, determine the fractions of the two conjugate forms.
- 4) Given the  $pK_a$  of a conjugate acid-base pair, the desired pH for a buffer solution, and the desired total molarity, determine the molarities of the two conjugate forms needed.

### Chapter 4 -Amino Acids, Peptides and Proteins, Chapter 5 -Protein Architecture

terminology:	$\alpha$ -amino acid	side chain	zwitterion	polypeptide
residue	protein	terminus (N, C)	peptidase	antibody
fibrous protein	globular protein	conjugated protein	multisubunit protein	native conformation

#### Objectives:

- 1) Know how to indicate protein amino acid sequence direction and know the three letter abbreviations for amino acid residues. Given a Fischer projection, know a D vs L amino acid. Know the amino acid classification by side group property.
- 2) Give a pair of amino acids with side chains as examples for these molecular interactions: hydrogen bonding, hydrophobic and ion-ion attractions.
- 3) Know the structural features of a peptide bond.
- 4) Be able to list an amino acid sequence for a peptide when given the side group properties needed at each residue.
- 5) Know the four levels of protein structure.

## EXAM 2 OBJECTIVES

### Chapter 8 – Carbohydrates: Structure and Biological Function

<b>terminology:</b>	monosaccharide	aldose	ketose	chiral center
Fischer projection	acetal	ketal	pyranose	furanose
anomer	anomeric carbon	Haworth projection	aldonic acid	lactone
glycoside	glycosidic bonds	oligosaccharides	starch	glycogen
cellulose	chitin	polysaccharide		mucopolysaccharides

- 1) Be able to interconvert Fischer and Haworth projections of any monosaccharide. Be able to identify D vs. L enantiomers and  $\alpha$  vs.  $\beta$  anomers.
- 2) Be able to recognize and/or give examples of structural isomers, stereoisomers, enantiomers, diastereomers, epimers and anomers.
- 3) Know the terminology for naming monosaccharide ring structures. Know the terminology for naming glycosidic bonds.
- 4) Know the Fischer and Haworth structures of ribose, xylose, ribulose, glucose, galactose and fructose.

### Chapter 9 - Lipids, Biological Membranes & Cellular Transport

<b>terminology:</b>	fatty acid	amphiphilic	acyl group	triacylglycerol
saturated	monounsaturated	polyunsaturated	bile salts	eicosanoids
glycerophospholipid	sphingolipids	steroids	cholesterol	terpenes
integral protein	peripheral protein	active transport	passive transport	facilitated diffusion
fluid mosaic model	lipid bilayer	glycolipid	high-density lipoprotein	low-density lipoprotein
concentration gradient	membrane potential	lipoprotein		

- 1) Be able to describe and/or draw representative structures of triacylglycerols, glycerophospholipids, eicosanoids, and steroid rings. Know the function(s) of these kinds of lipids.
- 2) Know the primary components and general features of cell membranes, HDLs and LDLs.
- 3) Understand the spontaneous direction for molecule (or ion) transport based on the concentration gradient and membrane potential.
- 4) Understand the terminology for the different types of membrane transport and be able to describe a transport process in these terms.
  - a) passive: mediated or nonmediated
  - b) active: primary, secondary
  - c) uniport, symport, antiport
  - d) electrogenic, electroneutral

## Chapter 10, 11, 12 - Nucleotides, Nucleic Acids and DNA Sequencing

<b>terminology:</b>	Nucleotide	Nucleic acid	DNA
RNA	Pyrimidine	Purine	Adenine
Guanine	Cytosine	Uracil	Thymine
Glycosidic bond	Pentose	Furanose	Nucleoside
Phosphoester linkage	Phosphoanhydride linkage	exonucleases	restriction endonucleases
electrophoresis	template	primer	DNA polymerase
dideoxynucleotides	PCR	RFLP	DNA fingerprinting

- 1) Understand the abbreviations for nucleotides. Know how to indicate nucleic acid base sequence. Understand the sequence direction of complementary nucleic acid strands.
- 2) Know the standard free energies associated with hydrolysis or condensation of phosphoanhydride bonds in nucleotide triphosphates. Know how ATP, ADP and AMP are converted.
- 3) Understand the general principles of electrophoresis and how this technique is used to separate oligonucleotides.
- 4) Understand the Sanger chain-termination sequencing method for DNA. Be able to interpret a final electrophoresis pattern from this method and write down the base sequence of the template studied.
- 5) Understand what the three repeating cycles of the polymerase chain reaction do.

## EXAM 3 OBJECTIVES

### Chapter 6, 7, 14 – Enzymes

<b>terminology:</b>	Conjugated protein	Prosthetic group	Glycoprotein	Lipoprotein
Nucleoprotein	Phosphoprotein	Metalloprotein	Holoenzyme	Apoenzyme
Catalytic power	Specificity	Lock and key and Induced fit models	Active (catalytic) site	Allosteric (regulatory) site
Cofactor	Coenzyme	Regulation	Covalent modification	Converter enzyme
Vitamin	Allosteric regulation	Effector	zymogen	isoenzyme
Transition state	Enzyme-substrate complex	Michaelis-Menten enzyme model	initial velocity	maximum velocity
Michaelis constant	Michaelis-Menten equation			

- A. Understand a reaction free energy diagram and how to interpret activation energy and transition state. Understand how a catalyst works with respect to this diagram. Calculate relative increase in reaction velocity from a lowering of  $E_a$  and vice versa. Understand the different ways that enzyme activity is regulated in cells.
- B. Be able to explain the binding characteristics between an enzyme and each the following: substrate, coenzyme, activator, competitive inhibitor, non-competitive inhibitor, uncompetitive inhibitor.
- C. Understand the common system of enzyme nomenclature: substrate + reaction type.
- D. Be able to provide examples or recognize examples of the types of reactions catalyzed by dehydrogenases, reductases, kinases, aminotransferases, hydrolases, hydratases, dehydratases, synthases, isomerases, mutases, polymerases, and synthetases and know the types of enzymes that typically utilize the following coenzymes: **FAD, NAD<sup>+</sup>, NADPH, PLP, and ATP.**
- E. Know the relationship between vitamins and coenzymes and why vitamins are needed for normal cell function.
- F. Understand Figures 6.4 and 6.5. Know how to find  $v_{max}$  and  $K_M$  from either kind of graph. Understand how each graph relates to percent of enzyme as ES.

## Chapter 14, 15, 16 - Metabolism Introduction & Carbohydrate Metabolism

<b>terminology:</b>	anabolic pathway	catabolic pathway	redox coenzymes	ATP energy cycle
flux	reciprocal regulation	covalent regulation	irreversible reaction	reversible reaction
glycolysis	phosphogluconate pathway	energy transduction	$\Delta G$	$\Delta G^{\circ}$
exergonic	oxidative phosphorylation	substrate-level phosphorylation	endergonic	fermentation

- A. Understand the general features of catabolic and anabolic pathways in metabolism - degradation or synthesis, oxidation or reduction, endergonic or exergonic.
- B. Know how to calculate  $\Delta G^{\circ}$  for coupled reactions from individual hydrolysis or condensation reaction  $\Delta G^{\circ}$  s.
- C. Know which pathways are the primary sources of ATP, NADH, NADPH, acetyl-CoA, pyruvate, and pentose phosphates.

### Pathways:

#### Glycolysis

- Kinases, substrate level phosphorylation; isomerase; synthase; mutase
- Irreversible reactions and regulation; phosphatases
- Glyceraldehyde-3-phosphate dehydrogenase oxidation step
- Structures: fructose-6-phosphate, glyceraldehyde-3-phosphate, 3-phosphoglycerate, pyruvate
- Overall reaction

#### Phosphogluconate Pathway

- Oxidative phase; dehydrogenases
- Connection to amino acid, lipid and nucleotide synthesis
- Non-oxidative phase; isomerase; synthase
- Carbon stoichiometry and connection to glycolysis
- Structures: 6-phosphogluconate, ribose-5-phosphate, ribulose-5-phosphate
- Overall reactions for phases and entire pathway

For all pathways discussed in class, you should be able to:

- Recognize the structures and names of substrates and products in all enzyme-catalyzed reactions discussed in lecture.
- Understand the free energy considerations (production and use of ATP), oxidation-reduction considerations (the general flow of electrons ( $H^{\cdot}$ ,  $H^{\cdot-}$ ) and carbon stoichiometry for each pathway.
- Know which enzymes are regulated for each pathway.

# EXAM 4 OBJECTIVES

## Chapter 15, 16 - Reactions of Pyruvate

<b>terminology:</b>	lactate dehydrogenase	fermentation	multienzyme complex
oxidative decarboxylation	carboxylation	aminotransferase	

- A. Conversion to lactate (enzyme and lactate structure)
- B. Conversion to ethanol and carbon dioxide
- C. Conversion to acetyl coenzyme A (dehydrogenase enzyme complex, coenzymes, acetyl CoA structure, overall reaction)
- D. Conversion to oxaloacetate (enzyme, oxaloacetate structure)
- E. Conversion to alanine

## Chapter 16 - Citric Acid Cycle

## Chapter 17 - Electron Transport and Oxidative Phosphorylation

<b>terminology:</b>	aerobic pathway	oxidation-reduction	electron transport chain
oxidative phosphorylation	mitochondria	membrane multi-enzyme system	oxidative decarboxylation
chemiosmotic coupling	concentration gradient	membrane electrical potential	ATP-ADP translocase

### Pathways:

#### Citric Acid Cycle

- A. Entry of acetylCoA; synthase
- B. Oxidative decarboxylations;  $\beta$ -ketoacids
- C. Dehydrogenase enzyme complex, coenzymes, acetyl CoA structure, overall reaction
- D. Substrate level phosphorylation
- E. Reactions to oxaloacetate
- F. Structures: citrate, oxaloacetate,  $\alpha$ -ketoglutarate, succinate
- G. Overall reaction; net production of ATP per acetylCoA

#### Mitochondrial Electron Transport Chain

- A. Oxidation-reduction; voltage and Gibbs free energy
  - B. Enzyme complexes; overall reactions
  - C. Mobile electron carriers; electron flow
  - D. Proton gradient generation; proton flow
  - E. Free energy of proton transport
  - F. ATP synthase; net production of ATP per NADH/H<sup>+</sup>; net production of ATP per FADH<sub>2</sub>
1. Know the overall redox reactions of the ETC that correspond to each of the four enzyme complexes and the electron carriers involved.
  2. Understand the terms in the free energy equation for transport of protons across a membrane. Be able to do the calculation.

## Chapter 18 - Lipid Catabolism

### Pathways:

#### $\beta$ -Oxidation of Palmitic Acid

- Acyl-CoA synthetase mechanism; ATP coupling
- Reactions of the 2 carbon cycle; dehydrogenases, hydratase, synthase
- Structures: acyl group, acetyl group, enoyl group,  $\beta$ -hydroxyacyl group,  $\beta$ -ketoacyl group
- Overall reaction; net production of ATP per palmitic acid

## Chapter 20 - Hydrophilic Hormones and Metabolic Regulation

glycogen phosphorylase	glycogen synthase	hormone-sensitive lipase	acetylCoA carboxylase
phosphoprotein	protein phosphatase	protein kinase	second messenger
hydrophilic hormone	insulin	glucagon	epinephrine

- Understand the general series of processes related to hydrophilic hormones binding to receptor proteins and the generation of second messengers.
- Understand the general principles of allosteric control of converter enzymes, covalent control of phosphoenzymes, reciprocal regulation of glycogen synthesis/degradation and reciprocal regulation of triacylglycerol synthesis/degradation.

## Chapter 19 - Amino Acid Catabolism

<b>terminology:</b>	branched chain amino acid	oxidative deamination	essential amino acid
nonessential amino acid	transamination	glucogenic	ketogenic

- Understand the general flow of nitrogen in animal amino acid catabolism and anabolism.
- Know the importance of aminotransferase reactions in amino acid biosynthesis and catabolism.
- Know the structures of the 3, 4 and 5 carbon,  $\alpha$ -ketoacid/ $\alpha$ -amino acid pairs in aminotransferase reactions. (pyruvate/alanine oxaloacetate/aspartate  $\alpha$ -ketoglutarate/glutamate)
- Know the structures and importance of glutamate and glutamine in carrying nitrogen.

### Pathways:

**Urea Cycle:** Overall reaction; structures: urea, carbamoyl phosphate

For all pathways discussed in class, you should be able to:

- Recognize the structures and names of substrates and products in all enzyme-catalyzed reactions discussed in lecture.
- Understand the free energy considerations (production and use of ATP), oxidation-reduction considerations (the general flow of electrons ( $H\cdot$ ,  $H^-$ )) and carbon stoichiometry for each pathway.
- Know the overall reaction for each pathway.