**Chapter 14 - Some Compounds with Sulfur, Oxygen, or Halogens: Alcohols, Phenols, Ethers,**

**Thiols, and Alkyl Halides**

Be able to:

1. Distinguish between alcohols, phenols, ethers, thiols, and alkyl halides.

2. Distinguish between an IMF and a chemical bond.

3. Characterize the major IMF in several carbon-based compounds.

4. List some uses of alcohols, phenols, ethers, thiols, and alkyl halides.

5. Identify some properties (chemical and physical) of alcohols, phenols, ethers, thiols, and alkyl

halides.

6. Provide correct IUPAC names (including common names) for alcohols, phenols, ethers, and

thiols.

7. Know the structure and name of some common diols such as ethylene glycol and glycerol

(glycerin) and explain why they often function as humectants in food and personal care

products.

8. Explain the relationship between intermolecular forces and the properties (polarity, solubility,

hydrogen bonding with other compounds, etc.) in alcohols, phenols, ethers, thiols, and alkyl

halides.

9. Compare the acidity of water, alcohols, phenols, mineral acids (HCl, HNO3, etc.) and

carboxylic acids ( RCOOH). Why are phenols more acidic than alcohols?

10. Characterize the oxidation or reduction of a hydrocarbon according to the changes in the

numbers of C – O and C – H.

11. Identify a dehydration or oxidation reaction of an alcohol.

12. Predict the products of a dehydration (major product) or oxidation reaction of an alcohol.

13. Describe the oxidation of an alcohol or glycol by enzymes in the liver.

14. Explain how a common chemical Breathalyzer indicates the concentration of blood alcohol.

15. List some characteristics of a free radical and its chain reaction.

16. Characterize the function of an antioxidant and explain the role of the phenol structure in the

antioxidant process.

17. Identify some common antioxidants found in nature and processed foods.

18. Diagram how sulfhydryl groups interact with heavy metal ions and explain how sulfur

participates in heavy metal poisoning.

19. Write the equation for the formation of a disulfide bond and characterize disulfide bond

formation as a reduction or oxidation. Explain your reasoning.

20. Identify and name a simple alkyl halide.

***Resveratrol***

**Chapter 15. Aldehydes and ketones**

Be able to:

1. Recognize a carbonyl group and characterize its polarity and shape.

2. Write structures and give names for common aldehydes and ketones.

3. Describe the general physical and chemical properties of aldehydes and ketones.

4. Demonstrate an understanding of the occurrence and use of aldehydes and

ketones.

5. Describe and predict the products of redox reactions of aldehydes and ketones,

6. Predict the outcome of Tollen’s test of some aldehydes and ketones.

7. Recognize acetals and hemiacetals.

8. Predict the acetal and /or hemiacetal formed from an alcohol and an aldehyde or

ketone.

9. Write the structure for the parent aldelhyde or ketone of an acetal or hemiacetal.

10. Explain the importance of hemiacetal chemistry in sugar structure.

**Chapter 16. Carboxylic acids and their derivatives**

Be able to:

1. Characterize the carboxyl functional group.

2. Compare the relative acidity of carboxylic acids,  and β carboxylic acids,

phenols, alcohols, water, and HCl.

3. Name and draw the structure of a carboxylic acid.

4. Know the structure and common name of formic, acetic, propionic, butyric, oxalic,

citric, lactic, salicylic, and benzoic acids

5. Write the equation for a neutralization reaction between a carboxylic acid and a

strong base. Name the carboxylate salt product.

6. Identify an alpha or beta hydroxy acid and explain how the hydroxyl group

contributes to their acidity.

7. Write the chemical reaction for the synthesis of aspirin from an acid and an

alcohol.

8. Predict the products of an esterification reaction.

9. Predict the products of an ester hydrolysis reaction.

10. Show how a saponification reaction is actually an ester hydrolysis by reaction

with base.

11. Predict the products of a reaction between an amine and a carboxylic acid.

12. Predict the products of an amide hydrolysis reactions.

13. Name simple esters and amides.

14. Characterize and name some polyamides and polyesters..

15. Give some examples of carboxylic acids, carboxylate salts, esters, and amides

used in everyday life.

16. Recognize and draw structures of phosphate esters and phosphate anhydrides.

17. Explain the importance of phosphoric anhydrides in biochemistry.

**Chapter 17. Amines and amides**

Be able to:

1. Recognize alkyl (1º, 2º, 3º) and heterocyclic amines as well as quaternary

ammonium ions/salts.

2. Name amines/amine salts. Write their structures.

3. Describe the general properties of amines, particularly solubility, boiling point,

hydrogen bonding, and acid-base interactions.

4. Compare the solubility and other properties of a quaternary amine salt with one

of its parent amine (free base) For example, trimethylammonium chloride vs.

dimethylamine.

5. Give some examples of amine salt pharmaceuticals and explain why they are

administered as amine salts.

6. Write equations showing acid-base interactions of amines.

7. Predict the form of an amine in physiological conditions (free base or conjugate

acid?)

8. Predict the physical properties of a free base and its ammonium salt.

9. Compare the basicity of an amine with weak bases such as other amines,

bicarbonate, and ammonia and strong bases such as hydroxide.

10. Characterize the alkaloid class of nitrogen containing compounds and

name/describe some common alkaloids.

**Chapter 18. Carbohydrates**

Be able to:

1. Describe some functions of carbohydrates.

2. Give a chemical description of carbohydrates.

3. Distinguish between monosaccharides, disaccharides, and polysaccharides.

Give examples of each.

4. Distinguish between an aldose and a ketose.

5. Name two amino sugars common in nature.

6. Compare the structure and properties of diastereomers and enantiomers

7. Identify diastereomeric and enantiomeric pairs of sugars.

8. Identify the chiral carbon atoms in monosaccharides.

9. Predict the number of isomers for different monosaccharides.

10. Draw and/or interpret the Fischer projection for a simple sugar. Indicate if the

structure is a D or L representation.

11. Draw and/or interpret the Haworth projection of a carbohydrate

12. Draw the open chain and cyclic forms of a monosaccharide and identify the

anomeric carbon.

13. Describe and draw the process of hemiacetal formation and explain its

relationship to monosaccharide structure.

14. Distinguish between anomers and stereoisomers.

15. Explain the process of mutarotation.

16. Characterize the properties of some common monosaccharides including

fructose, glucose, galactose.

17. Identify reducing sugars and the products of their oxidation.

18. Describe the glycosidic linkages between monosaccharides.

19. Characterize the structure of the disaccharides maltose, lactose, and sucrose.

20. Explain the function of some enzymes associated with carbohydrate hyrolysis –

lactase, galactosidase, and invertase

21. Describe the structure of hyaluronic acid and heparin.

22. Compare the structure of vegetable gums, cellulose, starch, and glycogen and

state their fates in metabolism.

23. Distinguish between corn syrup and high fructose corn syrup.

24. Describe the process used to make high fructose corn syrup.

25. Explain the relationship between carbohydrates and blood type.

**Chapter 19. Lipids**

1. Describe the chemical structure and general properties of fatty acids, waxes,

and oils.

2. Compare the properties of saturated and unsaturated fatty acids.

3. Name two essential fatty acids and identify them as omega-3 and/or omega –

6 fatty acids.

4. Explain why paraffin is not a true wax.

5. Compare the structure of plant and animal triglycerides.

6. Predict the products of hydrogenation, saponification, and acid hydrolysis of

triglycerides (triacylglcerols).

7. Explain why unsaturated fats have a shorter shelf-life than saturated fats.

8. Compare the properties and structure of a soap and a detergent molecule.

9. Describe the function of a surfactant.

10. Compare the structure, functions and properties of phospholipids, glycolipids,

and cholesterol.

11. Distinguish between a sphingolipid and a glycerophospholipid.

12. Characterize the structure of a lipid bilayer and a liposome. Describe some

uses of liposomes.

13. Describe the structure and function of prostaglandins and leukotrienes.

14. Explain the relationship between the pharmacology of aspirin and

cyclooxygenase enzymes.

15. Explain the function of cholesterol in a cell membrane.

16. Describe the general structure of a cell membrane and its chemical

composition.

**Chapter 19. Proteins**

Be able to:

1. Characterize the structure of a protein using the terms polymer, monomer, amino

acid, peptide bond, amide, and amino acid side chain.

2. Describe several types of functions of proteins.

3. Identify an α - amino acid.

4. Compare the polarity of the side chains of several amino acids and classify the

side chains as hydrophobic, hydrophilic, non-polar, polar, neutral, basic, or

acidic.

5. Compare the essential and non-essential amino acids.

6. Predict the structure of an amino acid in acidic solution and basic solution.

7. Illustrate the acid/base properties of amino acids and describe how the structure

of an amino acid depends on pH.

8. Explain the relationship between the zwitterions form of an amino acid and its

isoelectric point (pI).

9. Explain how the laboratory technique of electrophoresis is used to characterize

proteins and amino acids.

10. Identify a chiral carbon.

11. Predict the products of any of the following reactions of amino acids,peptides,

and /or proteins

• peptide formation

• hydrolysis of a polypeptide

• oxidation of cysteine to form a disulfide bond

12. Distinguish between primary, secondary, tertiary, and quaternary structure of

proteins.

13. Compare different types of secondary protein structure (alpha helix, etc.).

14. Identify the N and C terminals of a peptide chain.

15. Describe the types of interactions involved in each level of protein structure

(covalent and non-covalent interactions).

16. Predict the side-chain interactions between two amino acids.

17. Draw the structure of a peptide given the structures of amino acid residues.

18. Distinguish between a fibrous and a globular protein. Give examples of each.

19. Characterize the chemistry of several modes of protein denaturation.

20. Give some examples of applications of proteins in everyday life.

**Chapter 21. Enzymes and Vitamins**

1. Characterize the function of a catalyst in a chemical reaction.

2. List some characteristics of enzymes.

3. Draw energy diagrams for uncatalyzed and catalyzed reactions.

4. Distinguish between absolute, relative, and stereochemical specificity.

5. Explain the function of cofactors and coenzymes in enzyme catalysis.

6. Distinguish between the six classes of enzymes.

7. Identify the class of an enzyme given the chemical reaction it catalyzes.

8. Interpret a systematic enzyme name.

9. Distinguish between the lock-and-key model and the induced-fit model of

enzyme catalysis.

10. Describe several mechanisms of catalysis.

11. Explain why enzyme assays can be diagnostically useful. Give some

examples.

12. Predict the effects of an increase in the concentration of substrate or enzyme

on the rate of an enzyme catalyzed reaction.

13. Describe the effects of temperature and pH on an enzyme catalyzed reaction.

14. Characterize several modes of enzyme regulation.

15. Distinguish between a positive allosteric regulator and a negative allosteric

regulator.

16. Explain the role of zymogens in enzyme regulation.

17. Distinguish between a competitive enzyme inhibitor and a non-competitive

enzyme inhibitor. Give some examples.

18. Explain the role of genetics in the regulation of enzymatic activity.

19. Explain the connection between enzyme activity and nutrition (specifically

minerals and vitamins).

**Chapter X. Chemical messengers**

Be able to:

1. Distinguish between a receptor, hormone, and neurotransmitter.

2. Compare the endocrine system and the nervous system.

3. Distinguish between a hormone and a neurotransmitter.

4. Describe the three major types of hormones.

5. Classify and characterize a hormone given its structure.

6. Explain the role of epinephrine in the “fight-or-flight” response.

7. Describe the role of cyclic AMP as a second messenger for epinephrine.

8. Describe some polypeptide and amino acid derivative hormones.

9. Identify a steroid hormone.

10. Know the three classes of steroid hormones.

11. Describe in general terms how a nerve impulse is passed from one neuron to

another.

12. Describe the role of acetylcholine and acetylcholinesterase in nerve impulse

transmission.

13. Given the mode of mechanism and outcome, classify a drug/compound as an

agonist or antagonist.

14. Characterize the three main monoamine neurotransmitters and the role of

monoamine oxidase in the chemistry of these compounds.

15. Describe the chemistry of addiction to cocaine and/or amphetamine.

16. Characterize the role of neuropeptides such as enkephalins in the body.

17. Show how some neuropeptides follow the morphine rule.

18. Characterize the structural similarities between histamines and

antihistamines and describe the mechanism of antihistamines in the reduction

of the allergic response.

19. Distinguish between the two types of histamine receptors.

20. Describe some methods of drug design.

**Chapter X. Bioenegitcs**

Be able to:

1. Explain role of Gibbs free energy change (ΔG) in determining if a reaction is

exergonic or endergonic, spontaneous or non-spontaneous.

2. Interpret reaction energy diagrams (ΔG vs. reaction progress).

3. Characterize the thermodynamic contributors to reaction spontaneity (ΔH and

ΔS).

4. State the relationship between ΔG, Keq, and the equilibrium state.

5. Provide an overview of the sources of our energy and how we use it.

6. Explain the term ”metabolic pathway” and give an example.

7. Distinguish between catabolic and anabolic reactions. Include the role of energy

in these processes.

8. Map out the basic cellular anatomy involved in the generation of biochemical

energy in humans.

9. Give general description of the four major stages of the production of biochemical

energy from food. (For each stage state the starting materials and the products,

what happens in that stage, and its connection to the overall process.)

10. Explain the significance of the acetyl group in acetyl SCoA. What is an acetyl

group? Where do the carbon atoms come from? What is its role in the citric acid

cycle?

11. Write a simple reaction for the hydrolysis of acetylSCoA. Is this process

endergonic or exergonic?

12. Characterize three major strategies of metabolism. Give examples of each.

13. State the full name of ATP.

14. Give a general description of the structure of ATP and explain why the loss of

one phosphate group stabilizes the structure. Use the terms phosphate

anhydride bond, phosphate, repulsion, and energy.

15. Compare the ΔG of the hydrolysis of a phosphoric ester bond and a phosphoric

anhydride bond.

16. Explain why a phosphate hydrolysis reaction that is substantially more

endergonic than that of ATP would not be very useful in metabolic reactions.

17. Write, using structural formulas, the equation for the hydrolysis of acetyl

phosphate.

O

P

O

O

O

C

O

CH3

18. Characterize the reverse reaction described above in # 17 as exergonic or

endergonic.

19. Distinguish between coupled reactions and reactions that occur simultaneously.

20. Explain why the ΔG of reaction coupled with ATP production must be more

endergonic that ΔG = -7.3 kcal/mol.

2

21. Characterize the oxidation or reduction of a carbon-based molecule and give

some examples.

22. Distinguish between a reduced and an oxidized coenzyme. Give some examples.

23. Give the full name of NAD, FAD, and FMN.

24. Show how the loss or gain of a hydrogen atom in enzyme catalyzed reactions is

equivalent to the loss or gain of an H+ and 2e. Use a reaction in your example.

25. Explain why reduced coenzymes are called electron carriers.

26. Explain why the symbols for the reduced coenzymes NADH/H+ and FADH2

always indicate 2H. What does this mean?

27. Which class of vitamins is incorporated into many of the reduced coenzymes?

28. State two other names of the citric acid cycle. Describe the origin of each name.

29. Describe the first step in the citric acid cycle.

30. State the main function of the citric acid cycle and list its end products.

31. Write the overall reaction of the citric acid cycle using a citric acid cycle diagram.

32. Give an example of how the rate of the citric acid cycle is controlled. (Would

accumulation of ADP act as a positive or negative regulator? What about excess

ATP?)

33. List the four electron carriers found in the electron transport system. Describe

their general structure and how they “carry” e.

34. Explain why electron carriers constantly undergo redox reactions.

35. Distinguish between a reduction and an oxidation reaction.

36. Provide a general scenario of electron transport. Include a description of its

participants – protein complexes, electron carriers (including mobile electron

carriers). What happens to the energy level as electrons are passed along the

electron transport chain?

37. Write the overall reaction for the series of reactions in electron transport. What

eventually is the final acceptor of electrons? Is this reaction endergonic?

38. State the main function of oxidative phosphorylation and explain why it is coupled

with electron transport.

39. Name the protein complex that facilitates the synthesis of ATP.

40. Explain how the chemiosmotic theory accounts for the energy requirements of

ATP synthesis. Use the terms electrochemical gradient, proton gradient, potential

energy, flow, ATP synthase, driving force, ion channel.

41. Explain the action and basic result of chemical “uncouplers”. Give some

examples of uncouplers – naturally occurring and synthetic.

42. Describe the action of some toxins that inhibit electron transport. (rotenone,

amytal, demeral, antimycin A, cyanide, carbon monoxide)

**Chapter 23 – Carbohydrate Metabolism**

Be able to:

1. Characterize the fate of glucose in the body when energy is needed by the

cells of the body. What is the first reaction of glucose when it enters the

cytosol? List the major steps of catabolism of a glucose molecule under

aerobic and anaerobic conditions.

2. Interpret the reactions of glycolysis noting characteristics of isomerization,

oxidation, reduction, coupling of reactions, energy flow, ATP formation, and

ATP hydrolysis.

3. Explain how ATP, ADP, and/or glucose – 6 – phosphate act as regulators for

glycolysis.

4. Explain why glycolysis cannot proceed without NAD+. (Where/how is NAD+

made?)

5. Give a general description of the chemistry of glycolysis. What are the

products of glycolysis?

6. Identify where in the cell glycolysis occurs.

7. Describe the fate of pyruvate in aerobic and anaerobic conditions. Under

what conditions does lactate form? acetyl-CoA ?

8. Explain the fate of pyruvate in yeast.

9. Explain how ATP is made under anerobic conditions. (Why is electron

transport not available under these conditions?)

10. Characterize the overall result of the oxidation of one glucose molecule

(aerobic condtions).

11. Describe the connection between body heat, the oxidation of glucose, and

ATP formation.

**Chapter 25 – Lipid Metabolism**

1. Describe the process of fatty acid activation. Where in the cell does it occur?

2. Explain why fatty acid oxidation is called beta oxidation. Where does fatty

acid oxidation occur?

3. Explain why beta oxidation of fatty acids is said to be a spiral rather than a

cyclic pathway.

4. Predict the number of spirals of beta oxidation that would be needed for a

given fatty acid.

5. Describe how the condition of ketoacidosis occurs. What chemical compound

is in short supply? Excess? What are ketone bodies?

6. Characterize the difference between sugars and fats in the context of ATP

production per carbon atom and the relative redox state of the carbon atoms

in fats vs. proteins.