

## Student Self-Assessment for Challenge Exam for CHEM 105

### AM I READY TO CHALLENGE CHEM 105?

This document is intended for student self-assessment purposes only. Review it carefully to determine if you are ready for the Challenge Exam for the course indicated above. Your self-assessment is not a guarantee that you will pass the Challenge Exam. Faculty with expertise in the subject matter evaluate whether your exam provides sufficient evidence that you have demonstrated appropriate college-level mastery of the course content. Enrolling in the course may be your best option.

#### LEARNING OUTCOMES:

This exam will test your knowledge and skills for the following Learning Outcomes:

#### Section 1 General Chemistry

##### Introductory Skills

- Review the metric system: meters, liters, grams prefixes: kilo-, milli-, centi-, deci-, micro-
- Distinguish between potential and kinetic energy
- Recognize if a change is physical or chemical
- Use scientific and standard (ordinary) notation
- Provide significant figures when indicated

##### Atomic Structure

- Define the phases of matter: solid, liquid & gas
- Describe the composition of protons, neutrons and electrons
- Distinguish atomic number, mass number and average atomic mass
- Outline the differences between metals, semimetals and nonmetals
- Name the groups in the periodic table
- Describe the atomic configuration of atoms & ions
- Recognize isotopes: Hydrogen and Carbon examples
- Distinguish between atoms, molecules & compounds
- Recognize ions, distinguish cations & anions

##### Ionic & Covalent Compounds

- Write correct formulae for ionic compounds given name or atomic symbols
- Name ionic compounds including those with the transition metals Fe and Cu
- Write correct formulae for ionic compounds using polyatomic ions (table will be provided)
- Distinguish between covalent & ionic bonds
- Utilize the duet and octet rules
- Draw Lewis electron dot and line-bond structures
- Name simple covalent compounds given formula or structure
- Draw a line bond structure from simple molecular formula
- Determine electronic geometry, molecular shape and bond angles in molecules

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- Recognize polar covalent and non-polar covalent bonds.
- Label polar covalent bonds using  $\delta+$  and  $\delta-$ .
- Determine if molecules are polar or non-polar
- Determine types of intermolecular forces of molecular attraction in molecules
- Order intermolecular forces of molecular attraction by strength
- Recognize the effect of intermolecular forces on melting and boiling points

### Chemical Quantities and Reactions

- Convert between formula/molecular weight, moles and numbers of atoms.
- Calculate density – given mass and volume
- Identify “reactants” and “products” as used in reactions
- Use stoichiometry to balance equations
- Convert between moles and grams for balanced reactions
- Define the terms exothermic and endothermic and predict heat flow.
- Write and balance a combustion reaction
- Distinguish between enthalpy and entropy
- Define the term “metabolism”
- Distinguish between catabolism and anabolism
- Draw energy of reaction diagrams for spontaneous and non-spontaneous reactions
- Recognize activation energy on an energy of reaction diagram
- Describe the role of catalysts and how they change the activation energy
- Predict how a reaction at equilibrium will shift according to Le Chatelier’s principle

### *Changes of State*

- Recognize the states of matter & their characteristics
- List the phase changes and which use or release energy
- Distinguish between heat and temperature
- Name the three temperature scales in common use
- Convert between  $^{\circ}\text{C}$  and K
- Know the value for the freezing/boiling point of water on all three scales

### Acids, Bases, Equilibrium & pH

- Identify acids and bases in reactions.
- Recognize the hydronium ion and the hydroxide ion
- Understand the term “conjugate base or acid”
- Define the term “amphoteric”, examples of amphoteric molecules
- Define & recognize “strong acid” and “weak acid”, strong base/weak base
- Predict whether an organic compound is an acid or base
- Describe Le Chatelier’s principle.
- Predict how changing the concentration of reactants affects equilibrium.
- Define  $K_w = [\text{OH}^-][\text{H}_3\text{O}^+] = 1 \times 10^{-14}$ .

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- Use  $K_w$  to calculate the  $[H_3O^+]$  or  $[OH^-]$  of a solution
- Understand the pH scale in terms of neutrality, acidic or basic solutions ie which is which.
- Define the term physiological pH
- Predict the structure of acidic and basic functional groups (carboxylic acids and amines) in neutral and ionic form, recognize which form prevails at physiological pH
- Relate pH to  $[H_3O^+]$  or  $[OH^-]$  using the pH equation  $pH = -\log [H_3O^+]$  (given either pH,  $[OH^-]$  or  $[H_3O^+]$ )
- Write and balance acid base neutralization reactions. Review formation of ionic compounds if hazy.
- Define the term “buffer”
- Describe the components of a buffer
- Define pka
- Recognize the importance of regulating blood pH

### Solutions and Concentration

- Distinguish between solution, solute & solvent
- Describe how solubility of solids, liquids and gases changes as a function of temperature
- Give real world examples of solubility in action: eg drug action
- Distinguish between colloids, suspensions & solutions
- Calculate concentration in mols/L (molarity, M)
- Calculate concentration as %w/v
- Interconvert between %w/v and molarity
- Calculate molarity given names or molecular formulae, number of moles, number of atoms
- Define osmosis, diffusion, semi permeable membrane, osmolarity
- Predict the movement of water between solutions separated by a semi permeable membrane.

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### Section 2 Organic and Biochemistry

#### *Alkanes, Alkenes & Aromatic Compounds*

- Name and draw simple alkanes and cycloalkanes
- Determine the molecular shape of simple alkanes, cycloalkanes & aromatics
- Distinguish between conformers and structural isomers
- Name and draw branched hydrocarbons
- Given names determine molecular formula, Lewis structure & skeletal line bond structure
- Name simple aromatic compounds
- Determine order of melting/boiling point of simple hydrocarbons

#### *Organic Functional Groups*

- Recognize the following groups: ketone, aldehyde, ester, amide, carboxylic acid, alcohol, amine, aromatic, alkene, alkyne, phenol, ether, thioester and phosphate.
- Name simple alcohols, ethers, ketones, aldehydes & carboxylic acids.
- Recognize the suffixes for molecules containing functional groups for example -ol, -al, -one etc
- Interconvert between molecular structures (Lewis structures), condensed molecular structures and skeletal line structures.
- Find the molecular formula for a molecule given any one of the previous types of structure.
- Apply symbols to indicate partial charges on polar functional groups
- Understand how each of the functional groups can interact with like molecules. Identify the strongest type of intermolecular force & relate to boiling point
- Recognize H-bond donors and acceptors.
- Identify polar functional groups that can hydrogen bond with water
- Predict water solubility of molecules, rank groups of molecules by their solubility
- Recognize the different classes of alcohols & amines.
- Identify functional groups that can donate or gain protons
- Recognize chiral molecules and identify chiral carbons.

#### *Carbohydrates*

- Recognize the molecular formula of a simple sugar.
- Distinguish between mono-, di- and polysaccharides, with examples.
- Recognize ketose and aldose sugars and name according to the number of carbons.
- Find chiral carbons in molecules
- Understand what is being represented in the Fisher projection
- Distinguish D and L stereoisomers. Which predominate in biological molecules?
- Recognize the structure of glucose (both linear and cyclic).
- Understand why sugars cyclize, label the anomeric carbon
- Distinguish  $\alpha$  and  $\beta$  anomers.
- Recognize pyranose and furanose structures
- Convert a linear structure into a Haworth projection and reverse

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- Know the monomeric components and bonding of the disaccharides: sucrose, lactose, maltose
- Understand how glycosidic bonds are named, recognize these bonds given structures
- Polysaccharides: know the monosaccharide components and types of bonds involved for the following: amylose, amylopectin, glycogen, cellulose
- Understand the roles of the above polysaccharides
- Recognize condensation and hydrolysis reactions
- Understand that carbohydrates are used as cellular markers example A, B O blood groups

### Lipids

- You should be able to recognize a fatty acid and label the hydrophobic and hydrophilic regions.
- Draw fatty acids as condensed and skeletal structures
- Recognize saturated and unsaturated fatty acids
- Relate the physical properties of fatty acids to their structure, chain length and presence of double bonds
- Understand the “short hand” delta notation for fatty acids eg C20:1 $\Delta$ 9
- Recognize omega-3 and omega-6 fatty acids
- Recognize a triglyceride and understand how they are formed, understand their function and relate physical properties to the fatty acids involved.
- Identify *cis* and *trans* fatty acids, which are the naturally occurring FAs?
- Understand the composition of membranes, identify the nonpolar and polar regions of the molecules
- Recognize the steroid nucleus.
- List the key molecules/classes of molecules produced from cholesterol.

### Proteins: Structure and Function (a table of amino acids will be included on the exam)

- Know the structure of a generic amino acid, identify the  $\alpha$ carbon, R groups, amine and carboxyl groups
- Understand how the amine, carboxyl and side chains would appear at low, physiological and high pH
- You should be able to classify amino acids according to their side chains by sight ie if I give you a structure
- Identify chiral carbons
- Bring two amino acids together to make a dipeptide
- Recognize peptide bonds and circle individual amino acids in a peptide.
- Describe the four levels of protein structure and be able to recognize each from a description.
- Identify the two common secondary structures: alpha helix, and beta sheet (parallel and antiparallel)
- Understand the term “backbone hydrogen bond”
- Alpha helix: structure, number of amino acids per turn, hydrogen bonds etc
- Beta sheet: parallel vs antiparallel, hydrogen bonding
- Tertiary structure: bonding between R groups, types of bonds found, which amino acids can participate in these bonds?
- Quaternary structure: definition, what types of proteins have this level of structure
- Types of bonds broken during denaturation

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- Recognize that enzymes are biological catalysts

### Nucleic Acids (*genetic code will be provided*)

- Know the components of nucleic acids
- Recognize the sugars found in DNA & RNA
- Know which bases are found in DNA & RNA, distinguish purines and pyrimidines.
- Understand how nucleotides link together to form strands of DNA & RNA; recognize the 5' and 3' ends
- Know Chargaff's rules and be able to use them.
- Understand the meaning of "sugar-phosphate" backbone, complementary bases and antiparallel with respect to the double helix of DNA.
- Be able to make a complementary strand of DNA when given a single strand.
- Describe the number of hydrogen bonds between base pairs.
- Understand the basic mechanism of replication
- Recognize coding and template strands of DNA
- Outline the differences between DNA and RNA
- List the major types of RNA and their roles in the cell
- Be able to transcribe a piece of RNA from DNA
- Read & use the genetic code provided
- Distinguish codon from anticodon
- Describe the basic mechanics of translation
- Translate mRNA into a polypeptide sequence
- Identify simple mutations: base insertion/deletion, reading frame changes

### CHALLENGE EXAM DESCRIPTION:

You will be asked to demonstrate your knowledge and skill related to the Challenge Course through these types of questions:

- Fifty Multiple-Choice questions on a 75 minute exam

### EXAMPLE EXAM ITEMS:

#### Chem 105 Challenge Exam Example Questions.

Copies of the periodic table, genetic code and structures of amino acids will be provided for the exam.

#### Section 1

1) Express 372,000 in scientific notation.

- A.  $372 \times 10^3$     B.  $3.72 \times 10^{-5}$     **C.  $3.72 \times 10^5$**     D.  $3.72 \times 10^4$     E.  $3.72 \times 10^{-4}$

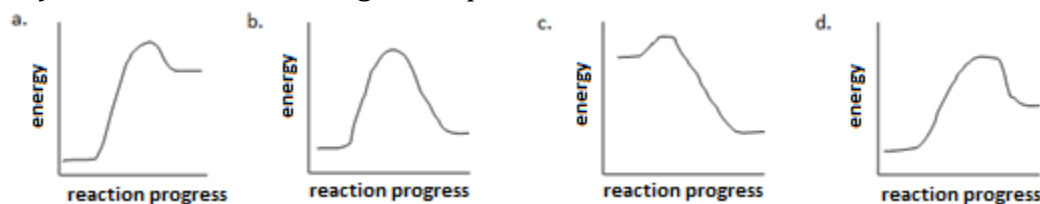
2) Which of the following measurements has three significant figures?

- A. 0.045 m    B. 450.0 m    C. 450 m    D. 0.045 m    **E. 0.0450 m**

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- 3) Convert 17 mg to kilograms.  
A.  $17 \times 10^{-4}$  kg    **B.  $1.7 \times 10^{-5}$  kg**    C. 0.17 kg    D.  $1.7 \times 10^5$  kg    E.  $1.7 \times 10^4$  kg
- 4) Convert 23 g into mg.  
A.  $2.3 \times 10^{-4}$  mg    B.  $2.3 \times 10^{-3}$  mg    C. 230 mg    **D.  $2.3 \times 10^4$  mg**    E.  $2.3 \times 10^{-2}$  mg
- 5) Select the correct name for this ionic compound,  $\text{Cu}_2\text{O}$ .  
A. Copperate    B. Copper oxygen    C. Dicopper oxide    D. Copper (II) oxide    **E. Copper (I) oxide**
- 6) The element in this list with chemical properties most similar to magnesium (Mg) is;  
A. potassium (K)    **B. calcium (Ca)**    C. lithium (Li)    D. aluminum (Al)    E. sodium (Na)
- 7) Acid rain causing corrosion on a limestone building is an example of;  
**A. a chemical change**    B. a physical change
- 8) A can of soda releasing gas when it opens is an example of;  
A. a chemical change    **B. a physical change**
- 9) Which of the following is not a covalent compound?  
A.  $\text{H}_2\text{O}$     B.  $\text{CH}_4$     C.  $\text{CO}_2$     D.  $\text{NH}_3$     **E.  $\text{CaO}$**
- 10) What is meant by the following symbols?  
$$\begin{array}{c} \delta^- \quad \delta^+ \\ \text{O}-\text{H} \end{array}$$
  
A. This means that the hydrogen has donated an electron to the oxygen.  
B. This means that the oxygen has donated an electron to the hydrogen.  
**C. This means that the oxygen is pulling electrons toward itself and is partially negative.**  
D. This means that the hydrogen is pulling electrons toward itself and is partially positive.  
E. These are not symbols used in chemistry.
- 11) Why does water ( $\text{H}_2\text{O}$ ) have a higher boiling point than methane ( $\text{CH}_4$ )?  
**A. Water forms hydrogen bonds and methane only forms dispersion forces.**  
B. Water forms dispersion forces and methane forms hydrogen bonds.  
C. Water has a higher molecular weight than methane.  
D. Methane has a higher molecular weight than water.  
E. Methane has more atoms than water.
- 12) How many moles of carbon are in 27.1 g of carbon?  
**A. 2.26 moles**    B. 325 moles    C. 0.443 moles    D. 4.52 moles    E. 163 moles
- 13) The balanced chemical equation for the combustion of butane is given below. How many grams of  $\text{O}_2$  are needed to completely react with 5.0 g of butane in a butane lighter?  
$$2 \text{ C}_4\text{H}_{10} + 13 \text{ O}_2 \rightarrow 8 \text{ CO}_2 + 10 \text{ H}_2\text{O}$$
  
A. 0.42 g    B. 2.8 g    C. 6.0 g    D. 9.1 g    **E. 18 g**

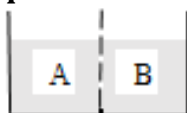
14) Which of the following corresponds to the fastest reaction? **C**



15) How many grams of dextrose are in 100 mL of D5W (5.0% dextrose)?

- A. 50 g    **B. 5.0 g**    C. 0.50 g    D. 0.050 g    E. 0.0050 g

The figure below represents two solutions (A & B) separated by a semi-permeable membrane that allows only water to cross. Use this figure to answer the next two questions.



16) If solution A is 0.6M potassium chloride and solution B is 0.4M potassium chloride, which statement most accurately describes what would happen?

- A) water will flow from A to B  
 B) potassium chloride will flow from B to A  
 C) potassium chloride will flow from A to B  
 D) water will flow back and forth between A and B  
**E) water will flow from B to A**

17) If solution A is 0.4M sodium chloride and solution B is 0.4M calcium chloride, which statement most accurately describes what would happen?

- A) water will flow from A to B**  
 B) calcium chloride will flow from B to A  
 C) sodium chloride will flow from A to B  
 D) water will flow back and forth between A and B  
 E) water will flow from B to A

18) What is the pH of a 0.08 M solution of HCl?

- A) 0.08    B) 8    C) -0.08    **D) 1.1**    E) -1.1

19) Find the pH of a solution with a  $[\text{OH}^-]$  of  $6 \times 10^{-5}\text{M}$ .

- A) 4.2    B) -4.2    C) 6.5    D) -9.7    **E) 9.7**

20) What is the conjugate base of  $\text{H}_2\text{PO}_4^-$  ?

- A)  $\text{H}_3\text{PO}_4$     B)  $\text{H}_2\text{PO}_3$     C)  $\text{HPO}_4$     **D)  $\text{HPO}_4^{2-}$**     E)  $\text{PO}_4^-$



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Section 2

1) A carbon-carbon triple bond consists of

- A. a shared electron pair
- B. three unshared electron pairs
- C. three electrons
- D. three shared electron pairs**
- E. two shared pairs and one unshared pair of electrons

2) Formaldehyde is used as a preservative and in disinfection. It has the structure shown below. What is the strongest type of intermolecular interaction attracting molecules of formaldehyde together?



- A. ionic bonding
- B. covalent bonding
- C. dispersion forces
- D. dipole-dipole forces**
- E. hydrogen bonding forces

3) What is the name of this molecule  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$ ?

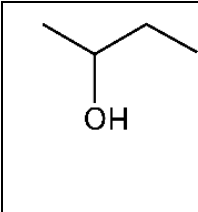
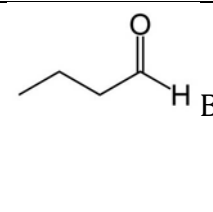
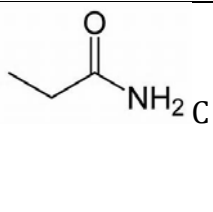
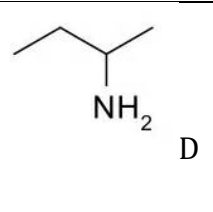
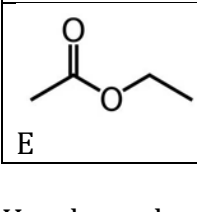
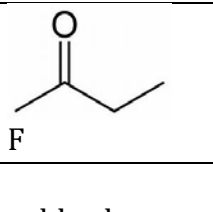
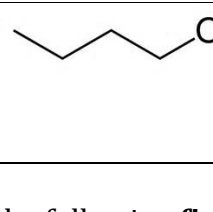
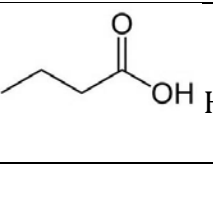
- A. butane**
- B. ethane
- C. propane
- D. hexane
- E. pentane

4) Which would have the highest boiling point?

- A. ethane
- B. butane
- C. hexane
- D. octane**
- E. pentane

5) An alkane with 5 carbon atoms would have \_\_\_ hydrogen atoms in the molecule.

- A. 5
- B. 8
- C. 10
- D. 12**
- E. 14

 A	 B	 C	 D
 E	 F	 G	 H

Use the molecules in the table above to answer the following **five** questions:

6) Which of the molecules are esters?

- A. only A
- B. A & G
- C. only B
- D. only E**
- E. only H

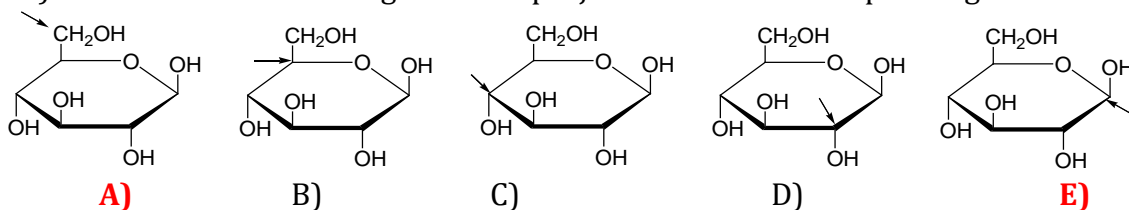
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- 7) Which molecules contain a carbonyl carbon?  
 A. A & G    B. all but D    C. B,E,F & H    **D. B,C,E,F & H**    E. all of them
- 8) Which pairs of molecules represent structural isomers?  
 A. A & G    B. B & F    C. E & H    D. none of these pairs    **E. all of these pairs**
- 9) Which of these molecules is butanoic acid?  
 A. molecule A    B. molecule B    C. molecule E    D. molecule G    **E. molecule H**
- 10) Which of these molecules is a ketone?  
 A. molecule B    B. molecule C    C. molecule E    **D. molecule F**    E. molecule H

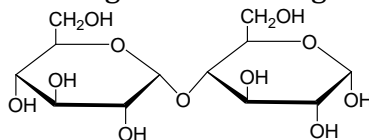


11. What is the IUPAC name of the molecule above?  
 A. 2-ethylpentan-5-ol                      D. 3-methylhexan-6-ol  
 B. 4-ethylpentan-1-ol                      E. 5-methylhexan-1-ol  
**C. 4-methylhexan-1-ol**
12. Which statement best describes why ethers have lower boiling points than alcohols of the same molecular weight?  
**A. Ethers cannot hydrogen bond to one another.**  
 B. Alcohols cannot hydrogen bond to one another.  
 C. Ethers can hydrogen bond with water.  
 D. Alcohols can hydrogen bond with water.  
 E. Ethers cannot hydrogen bond with water.
- 13) All simple sugars have the formula:  
 A)  $\text{CH}_2\text{O}$     B)  $\text{C}_2\text{H}_2\text{O}$     C)  $(\text{CHO})_n$     **D)  $(\text{CH}_2\text{O})_n$**     E)  $\text{C}_6\text{H}_{12}\text{O}_6$

- 14) In which of the following Haworth projections is the arrow pointing to the anomeric carbon?



- 15) Which of the following glycosidic linkages does the sugar shown below contain?



- A)  $\beta$ -2,4    **B)  $\alpha$ -1,4**    C)  $\beta$ -1,4    D)  $\alpha$ -2,4    E)  $\alpha$ -2,6

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- 16) Triglycerides are formed by the \_\_\_ reaction between fatty acids and glycerol.  
**A) esterification reaction**  
B) glycosidic reaction  
C) glyceride reaction  
D) hydrolysis reaction
- 17) Which amino acid is classified as basic?  
**A) histidine** B) glutamic acid C) aspartic acid D) glycine E) methionine
- 18) Which tripeptide would be the most soluble in water at pH 7?  
A) met-gly-ala B) gly-ser-val C) phe-lys-gly D) lys-glu-arg E) asp-gly-lys
- 19) Disulfide bonds are found between the  $\alpha$ -helices on the A chain of insulin. Which level of protein structure are these bonds contributing toward?  
A) primary B) secondary **C) tertiary** D) quaternary
- 20) Which of the following statements is NOT correct about enzymes?  
A) Enzymes have a temperature at which they function best (optimum temperature).  
B) Enzymes can be used over and over again.  
C) Enzymes bind with their substrates in such a way that the reaction can occur more readily.  
**D) Enzymes are not susceptible to changes in pH.**  
E) Enzymes lower the energy of activation for a reaction
- 21) Which of the following statements best describes why the sugar-phosphate nucleic acid backbone is on the outer part of the DNA double helix while the nitrogen bases are on the inside of the double helix?  
**A) The sugar phosphate backbone is hydrophilic while the bases are hydrophobic.**  
B) The sugar phosphate backbone is hydrophobic while the bases are hydrophilic.  
C) The sugar phosphate backbones of the two strands are bonded together.  
D) The nitrogen bases are covalently bonded to each other.  
E) There is no reason; the structure is just that way.
- 22) Which amino acid is coded for by the codon GCC?  
A) Serine B) Aspartic Acid C) Alanine D) Valine E) Glycine
- 23) During protein synthesis, peptide bonds are formed at the  
A) nucleus B) nucleolus C) lysosomes **D) ribosomes** E) helicases

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24) Purines include

- A) cytosine, uracil, and thymine
- B) adenine and cytosine
- C) adenine and thymine
- D) cytosine and thymine
- E) adenine and guanine.**

25) Translation of messenger RNA into protein occurs in a \_\_\_\_\_ direction, and from \_\_\_\_\_ terminus to \_\_\_\_\_ terminus.

- A) 3'-to-5'; N; C
- B) 5'-to-3'; N; C**
- C) 3'-to-5'; C; N
- D) 5'-to-3'; C; N
- E) 3'-to-5'; C; N

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### DETERMINATION OF CHALLENGE EXAM OUTCOME:

You will need to earn the following to be awarded credit through Challenge Exam for this course:

- 70% Correct on **both** sections of the exam. Each multiple choice question is worth 2 points, there will be a total of 50 questions: 20 questions on section 1 and 30 questions on section 2.

### ITEMS YOU MAY BRING/USE DURING THE EXAM:

- Scientific calculator
- Periodic table (provided)
- Amino acid structures (provided)
- Genetic code (provided)