

## CHEM 365 First Practice Examination

- Which of the following statements is correct regarding a main function of carbohydrates?
  - They function to transmit and express genetic information.
  - Carbohydrates can act as enzymes and catalyze important biological reactions.
  - They function directly in the transportation of gases.
  - They provide the raw material for building other biological macromolecules.
- What is the approximate estimate of how long ago our planet formed?
  - ~4.6 billion years ago
  - ~2007 years ago
  - ~4.6 million years ago
  - ~3.5 billion years ago
- In 1953 Stanley Miller and Harold Urey performed a famous experiment in which they subjected a mixture of  $\text{H}_2\text{O}$ ,  $\text{CH}_4$ ,  $\text{NH}_3$ , and  $\text{H}_2$  to an electric discharge for about 1 week. These chemicals are believed to make up the atmosphere of prebiotic earth. Which of the following were NOT among the compounds found in the resulting solution?
  - simple nucleic acids
  - simple acids
  - simple amino-acids
  - acetic acid
- It is the year 2050. You are a space explorer and you're about to leave on a deep space mission to another solar system. Your boss tells you that you may only bring relatively simple molecules that will be used to synthesize all your food. You know, from taking Dr. Love's class, which atoms are essential for your life. Which of the following sets of molecules would provide the most complete set of atoms essential for life on our planet?
  - ATP, sodium chloride,  $\text{NH}_4\text{Cl}$
  - glucose, potassium phosphate, sodium chloride
  - methane, acetyl coenzyme A (CoA), sodium chloride
  - glucose, potassium phosphate, sodium chloride
- Which of the following statements about chemical evolution is correct?
  - Chemical evolution followed molecular (polymer) evolution which followed the evolution of cellular life on our planet.
  - The first complex chemicals that appeared on earth were produced from the condensation of the simpler chemicals that existed on prebiotic earth. These more complex molecules formed spontaneously upon input of energy (*e.g.*, from the sun or lightning or heat from volcanic sources).
  - No one has yet been able to experimentally reproduce or simulate what is believed to be the chemical or energetic conditions that probably existed on prebiotic earth.
  - Simple molecules hydrolyze to form polymers of repeating units.

6. In regards to the spontaneity of a chemical reaction within cells (*i.e.*, *in vivo*), which of the following statements is incorrect?
- [A] If  $\Delta G^\circ$  is positive the overall reaction is considered to be endergonic and thus the reaction cannot be spontaneous.
  - [B] The presence of an enzyme catalyst does not affect the final equilibrium concentrations of the products and reactants.
  - [C] If the concentration of the products of the reaction is sufficiently less than that of the reactants  $\Delta G$  may be negative.
  - [D] When  $\Delta G$  is equal to zero the reaction is at equilibrium.
7. Which do the following statements about evolution is correct?
- [A] Two key facets of evolution are variation (diversity) and selection.
  - [B] Since bacteria represent the largest biomass on the earth, and live and thrive in more places on earth than any other organism, they are considered to be the pinnacle of evolution.
  - [C] Humans, the most adaptable organisms on the planet, are the pinnacle of evolution.
  - [D] Humans could never have shared a common ancestor with mountain gorillas.
8. Which do the following statements about living systems and energy is correct?
- [A] Living organisms, which take up nutrients, release waste products, and generate work and heat, are open systems and therefore exist in a constant state of equilibrium.
  - [B] Animals ingest low-enthalpy, high-entropy nutrients, and convert them to high enthalpy, low-entropy waste products.
  - [C] Living organisms become more ordered as they grow and are thus entropically unfavorable. This provides evidence that life ignores the second law of thermodynamics.
  - [D] Complex life exists because a system could be ordered at the expense of disordering its surroundings to an even greater extent.
9. Which of the following statements about Gibbs free energy,  $\Delta G$ , is correct?
- [A] If  $\Delta H$  is positive, a very negative  $\Delta S$  can drive the process to be spontaneous.
  - [B] If  $\Delta H$  is positive, and  $S$  negative, the process may be spontaneous at high temperatures.
  - [C] If  $\Delta H$  is positive, and  $\Delta S$  is positive the process may be spontaneous at high temperatures.
  - [D] If  $\Delta S$  is negative, a very positive  $\Delta H$  can drive the process to be spontaneous.
10. Which of the following statements about the Second Law of Thermodynamics is incorrect?
- [A] Steam at  $100^\circ\text{C}$  has higher entropy than water at  $100^\circ\text{C}$ .
  - [B] An unfolded protein in a random coil state has higher entropy than the same protein in its folded, low-energy, native structure.
  - [C] The water molecules that surround and bind a hydrophobic amino acid in an unfolded protein are entropically favorable (*i.e.*, positive  $\Delta S$ ).
  - [D] The universe (as a whole) is becoming less ordered.

11. Which of the following statements about the hydrolysis of ATP is incorrect?
- [A] Intact ATP experiences greater resonance stabilization in comparison to its hydrolysis products.
  - [B] The solvation energy of intact ATP is less than that of the hydrolysis products.
  - [C] The hydrolysis of ATP releases energy and is therefore considered an exothermic process.
  - [D] The destabilizing effect of electrostatic repulsion between the charged groups of ATP is decreased upon hydrolysis.
12. Which of the following statements is correct about the molecular basis of using soap for cleaning purposes?
- [A] The soap molecules are not amphiphilic and therefore cannot form micelles.
  - [B] The main purpose of the polar head group is to render the soap molecule soluble in water.
  - [C] The function of the polar head group is to bind hydrophilic dirt particles.
  - [D] The greasy parts of dirt tend to partition to the hydrophilic portion of the soap micelles.
13. Which of the following statements about bond energies in biomolecules is incorrect?
- [A] Most covalent bonds are 10 to 100 times stronger than non-bonded interactions.
  - [B] The energy associated with electrostatic interactions is partially dependent on the physical properties of the medium in which the charges exist.
  - [C] Gasoline, which is classified as a hydrocarbon, is a liquid at room temperature because of the intermolecular hydrogen bonds it forms with H<sub>2</sub>O.
  - [D] Biomolecules that form hydrogen bonds will tend to have higher boiling points in comparison to biomolecules that cannot form hydrogen bonds.
14. Which of the following statements about the hydrophobic effect is incorrect?
- [A] The large change in enthalpy (*i.e.*, a large negative  $\Delta H$ ) is the major driving force.
  - [B] In an unfolded protein, tightly bound, caged water molecules form around exposed hydrophobic, non-polar side-chains. Upon folding the caged waters are released which is an entropically favorable process.
  - [C] The water molecules that are physically closest to the hydrophobic compound are, on average, more highly hydrogen bonded compared to liquid water.
  - [D] When oil is mixed with water the oil spontaneously coalesces into droplets so as to minimize its surface area exposure to water.
15. Which of the following statements is incorrect about the ionization of water?
- [A] The equilibrium constant for the ionization of water,  $K_w$ , is  $1 \times 10^{-14}$ .
  - [B] Two water molecules spontaneously ionize into  $2\text{H}_2^+$  and  $\text{O}_2^-$ .
  - [C] The concentration of  $[\text{H}^+]$  is directly dependent to the concentration  $[\text{OH}^-]$ .
  - [D] After ionization  $\text{H}^+$  actually exists as  $\text{H}_3\text{O}^+$ .

16. Which of the following statements about H<sub>2</sub>O is incorrect?
- [A] Even though water and proteins are very different in size (*i.e.*, molecular weight), water does have a great influence on the folded structure of proteins.
  - [B] Even though frozen water (*i.e.*, ice) has approximately 15% more hydrogen bonds than liquid H<sub>2</sub>O it is less dense than liquid water.
  - [C] Water (H<sub>2</sub>O) and methane (CH<sub>4</sub>) have similar molecular weights and thus their boiling points are also highly similar.
  - [D] Upon evaporation, hydrogen bonds between gaseous water molecules are broken and therefore evaporation is enthalpically unfavorable yet entropically favorable.
17. Which of the following statements about pK<sub>a</sub> is incorrect?
- [A] Since pK<sub>a</sub> values reflect the electronic states of ionizable groups, the actual pK<sub>a</sub> values of side-chains in a folded protein can be calculated by using the Coulombic equation.
  - [B] Titration of a weak base with a strong acid does not alter the pK<sub>a</sub> value of the weak base because pK<sub>a</sub> values are independent of pH.
  - [C] The pK<sub>a</sub> is equal to the pH when the conjugate base concentration is equal to that of the acid.
  - [D] The actual pK<sub>a</sub> value of an amino-acid side-chain in a folded protein depends on the local environment surrounding the side-chain and may differ from the “textbook” pK<sub>a</sub> value.
18. Which of the following statements about osmosis is correct?
- [A] At sea-level osmotic pressure is equal to 1 atmosphere.
  - [B] The act of applying urine to a stingray injury functions to accelerate healing by exploiting the osmotic properties of the urine and venom molecules.
  - [C] The process of osmosis is not colligative and therefore completely depends on the specific chemical features of the particular solvent and solute.
  - [D] Osmosis is the movement of a solvent through a semipermeable membrane into a solution of higher solute concentration that tends to equalize the concentrations of solute on both sides of the membrane.
19. Which of the following statements about the nitrogenous bases found in DNA and RNA is correct?
- [A] They contain all the atoms essential for life.
  - [B] There are two purines which each consist of two fused rings and three pyrimidines which each consist of just one ring.
  - [C] They absorb light in the visible electromagnetic range but not in the ultraviolet range.
  - [D] They are aromatic and therefore prefer the lower energy chair conformation.

20. Which of the following statements about RNA and DNA is incorrect?
- [A] Since salts have little to no effect on the strength of hydrogen bonds, the melting temperature of DNA is also not affected by different salt concentrations.
  - [B] Under normal solution conditions DNA exists in the B-form double helix geometry whereas RNA forms a more globular shaped structure.
  - [C] There are two Watson-Crick hydrogen bonds between the DNA bases AT as well as the RNA bases AU.
  - [D] Even though the secondary structure of RNA consists primarily of stems and loops its tertiary structure is usually globular.
21. Which of the following is incorrect about the data used as key pieces of information by Watson and Crick to elucidate the structure of DNA?
- [A] DNA has equal numbers of adenine and guanine residues and equal numbers of cytosine and thymine residues (Chargaff's rules).
  - [B] X-Ray diffraction studies (principally by Rosalind Franklin) revealed that the polymer is most likely helical with uniform width.
  - [C] Structural studies had indicated that the nitrogenous bases should assume the keto tautomeric form.
  - [D] Chemical evidence indicated that the polymer was linked by phosphodiester bonds between the 3' and the 5' carbons of adjoining ribose units.
22. Which of the following statements about the peptide bond in proteins is incorrect?
- [A] There is resonance sharing of electrons between the carbonyl oxygen, the carbonyl carbon and the attached nitrogen that results in the C-N bond having 40% double bond character.
  - [B] The C-N bond length tends to be slightly shorter than an average C-N single bond.
  - [C] The C=O bond length is slightly longer than an average C=O bond length.
  - [D] Since the C-N bond is a single bond there is free rotation around the C-N bond.
23. Which of the following statements about circular dichroism (CD) is incorrect?
- [A] CD can be used to determine if a protein is folded or unfolded (random coil).
  - [B] It can applied to the study of DNA but not proteins because one of the 20 amino acids that make up proteins is not chiral.
  - [C] It is form of spectroscopy that is used to determine the type of secondary structure of a particular protein.
  - [D] CD is a measure of the degree by which light is circularly polarized.
24. If you wanted to generate all the peptide sequences that a hexapeptide (*i.e.*, 6 residue positions) could consist of using only 2 different amino acids how many sequences would you generate?
- [A] 25
  - [B] 32
  - [C] 64
  - [D] 160

25. Subjecting a protein solution to extremes of pH can result in protein denaturation. Which of the following is the most likely cause of the denaturation?
- [A] Inversion of the hydrophobic effect.
  - [B] Greater induction of the hydrophobic effect.
  - [C] Disruption of bonds between ionizable side chains.
  - [D] Disruption of London dispersive forces.
26. Which of the following statements about the yeast functional complementation experiment is correct? **[The material for this type of question will not be covered on your first exam.]**
- [A] Since yeast contain very few introns it is possible to generate a library of expressible yeast genes by cutting the yeast genomic DNA such that the resulting pieces are approximately 10,000 base pairs in length.
  - [B] The yeast genome is digested with the enzyme *Sau3A* which produces the same blunt ends as *Bam*HI.
  - [C] Included on the shuttle plasmid is a yeast selectable marker such as *URA3*, which allows *ura3<sup>-</sup>* mutant bacteria to grow in the presence of yeast that provide the bacteria with essential uracil.
  - [D] One plasmid vector is utilized for bacteria and a different second plasmid is used for faithful replication of the target protein in yeast.
27. Which of the following statements about DNA sequencing is correct?
- [A] The primer is elongated 3'-5' in a reaction mixture containing the four normal deoxyribonucleotide triphosphates (dNTPs) plus a molar excess of the four dideoxyribonucleotide triphosphates (ddNTPs).
  - [B] The first step entails the high temperature hybridization of a small synthetic DNA plasmid to the double stranded template to be terminated.
  - [C] The goal of using the dideoxyribonucleotide triphosphate (ddNTP) chain terminators is to generate a pool of oligonucleotide strands that each differ by one nucleotide.
  - [D] The pool of oligonucleotide strands is resolved by HPLC and the order of appearance of each of the two different ultraviolet dyes at the end of the HPLC run is discarded.
28. Which of the following statements about the polymerase chain reaction (PCR) is correct?
- [A] The primary goal of PCR is to reverse transcribe RNA into DNA.
  - [B] PCR utilizes a polymerase that is temperature sensitive and therefore the reaction is stopped (quenched) in the final cycle when the temperature is raised to 95° C.
  - [C] The final PCR product includes the sequence of the target sequence of DNA but not the sequences of the primers.
  - [D] The final PCR product includes the sequence of the target sequence of DNA and also the sequences of the primers.

29. Which of the following statements about cDNA libraries is correct?

[This type of question will not be covered on your first exam.]

- [A] The purified mRNA is converted to DNA upon the use of the enzyme DNA ligase.
- [B] A restriction enzyme is used to cut up the total cellular DNA such that fragments are generated that, on average (*i.e.*, statistically), will contain entire genes.
- [C] Complementary sticky ends are used to ligate the generated cDNA into a plasmid vector using the enzyme reverse ligase.
- [D] The first step in generating a cDNA library is to isolate the total cellular mRNA with a column to which short strings of thymine (oligo-dTs) are linked to a matrix.

30. Which of the following statements about bacterial protein expression systems is correct?

- [A] It is only possible to produce bacterial proteins from bacteria. Eukaryotic proteins can only be produced in a eukaryotic expression system (*e.g.*, HeLa cells).
- [B] Upon transfection of a plasmid into bacteria almost all of the bacteria within the tube used for transfection will gain antibiotic resistance.
- [C] The chemical IPTG, which is an analog of lactose, is added to the growing bacteria where upon uptake it induces the bacteria to start producing the protein of interest.
- [D] Bacterial expression plasmids must contain a URA3 selectable marker that enables them to grow in the absence of uracil.

31. Which of the following sequences for two 12-residue primers could be used to amplify the following segment of template DNA using PCR?

5'GGCTAGGCATAGATACCCTAGTACTAGGTTTCCCATATTATTATCAGGTCTC-3'

- A) 5'-CCGATCCGTATC-3'; 5'-TTATTAGGTCTC-3'
- B) 5'-GGCTAGGCATAG-3'; 5'-GAGACCTGATAA-3'
- C) 5'-TATCCGTATCTA-3'; 5'-CTGACCTAATAA-3'
- D) 5'-CTATGCCTAGCC-3'; 5'-GAGACCTAATAA-3'

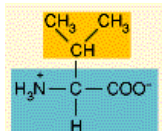
32. In the tetrapeptide Lys-Pro-Ile-His, there are \_\_\_\_\_ positively charged groups at pH 8.03, and the net overall charge for the molecule is \_\_\_\_\_.

- A) four, zero
- B) four, four
- C) two, one
- D) two, two

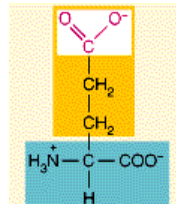
For questions 33-37 match the image of the following amino acids to the appropriate name.

- |                    |                 |                    |               |
|--------------------|-----------------|--------------------|---------------|
| [AB] Valine        | [AC] Alanine    | [AD] Tryptophan    | [AE] Leucine  |
| [BC] Lysine        | [BD] Asparagine | [BE] Glutamic Acid | [CD] Arginine |
| [CE] Phenylalanine | [DE] Histidine  |                    |               |

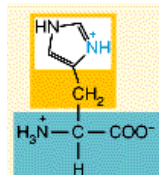
33.



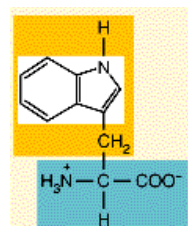
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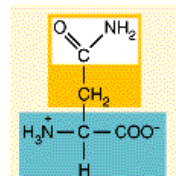
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36.



37.

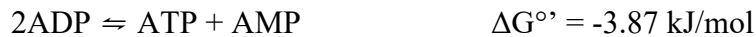


The following questions involve performing calculations to obtain the correct answers. Therefore you must perform the calculations and then choose the correct answer from the list of ten possible answers. All answers from this point on will entail the use of two letters.

38. You take an absorbance reading of your favorite protein on a UV-Vis spectrophotometer and your reading at 280.0 nm is 7.290. The path-length of your cuvette is 1.000 cm. You know that your extinction coefficient is  $18.672 \text{ (M} \cdot \text{cm)}^{-1}$  and therefore you calculate your concentration to be which of the following values

- |                |                  |               |                |
|----------------|------------------|---------------|----------------|
| [AB] 190.4 mM  | [AC] 290.4 mM    | [AD] 390.4 mM | [AE] 490.4 mM  |
| [BC] 570.4 mM  | [BD] 750.4 g/mol | [BE] 40.57 mM | [CD] 2.0 g/mol |
| [CE] -345.2 mM | [DE] 673.2 M     |               |                |

39. If intracellular  $[\text{ATP}] = 51.7 \text{ mM}$ ,  $[\text{AMP}] = 5.02 \text{ mM}$ , and  $[\text{P}_i] = 10.5 \text{ mM}$ , which of the following is the correct concentration of ADP at pH 7.00 and  $25^\circ \text{ C}$  under the condition that the adenylate kinase reaction is at equilibrium?



- |                                      |               |              |               |
|--------------------------------------|---------------|--------------|---------------|
| [AB] $5.44 \times 10^{-5} \text{ M}$ | [AC] 290.4 mM | [AD] 82.8 mM | [AE] 97.2 mM  |
| [BC] 0.828 mM                        | [BD] 69.7 mM  | [BE] 87.6 mM | [CD] 0.625 mM |
| [CE] 7.38 mM                         | [DE] 37.24 M  |              |               |

40. For the reaction  $\text{A} \rightarrow \text{B}$  at 298 K, the change in enthalpy is  $-2.970 \text{ kJ/mol}$  and the change in entropy is  $-32.30 \text{ J/mol K}$ . Below what temperature does the reaction become spontaneous?

- |                              |                               |                               |                                |
|------------------------------|-------------------------------|-------------------------------|--------------------------------|
| [AB] $143.0^\circ \text{ C}$ | [AC] $91.95^\circ \text{ C}$  | [AD] $689.0^\circ \text{ C}$  | [AE] $-131.0^\circ \text{ C}$  |
| [BC] $297.0^\circ \text{ C}$ | [BD] $-420.7^\circ \text{ C}$ | [BE] $-181.0^\circ \text{ C}$ | [CD] $-1435.0^\circ \text{ C}$ |
| [CE] $426.8^\circ \text{ C}$ | [DE] $22.79^\circ \text{ C}$  |                               |                                |