2024 SMH Invitational Cup - FINALS 1

TOSSUP

1) Biology – *Multiple Choice* An individual with which of the following disorders would be LEAST likely to exhibit symptoms similar to type 2 diabetes?
W) acromegaly
X) Addison's disease
Y) Cushing's disease
Z) Graves' disease

ANSWER: X) Addison's disease [SO]

BONUS

1) Biology – *Multiple Choice* The enzyme baconase converts probacon to bacon. In order to function, its active site requires the close interaction of a lysine residue and a glutamate residue. Which of the following is most likely to happen to the rate of production of bacon if the lysine residue is phosphorylated?
W) increase
X) decrease
Y) remain unchanged
Z) stop completely

ANSWER: X) decrease [SO]

TOSSUP

2) Chemistry – *Short Answer* What type of reactive intermediate forms from the alpha elimination of chloroform?

ANSWER: carbene [BL]

BONUS

2) Chemistry – *Short Answer* Name all of the following three gasses that increase in temperature upon expansion at room temperature:
1) Hydrogen
2) Oxygen
3) Neon

ANSWER: 1 and 3 [CZ]

TOSSUP

3) Physics – *Short Answer* Researchers first experimentally confirmed the physical existence of quarks by bombarding hadrons with extremely high energy electrons, muons, and neutrinos. What is this scattering process, which can be considered a high-energy extension of Rutherford scattering?

ANSWER: deep inelastic scattering [DL]

BONUS

3) Physics – *Short Answer* Grace constructs an RC circuit with a 2 megaohm resistor and a 4 microfarad capacitor. The capacitor is initially charged to 8.1 microcoulombs. Assuming e is equal to 2.7, and giving your answer to 2 significant figures and in scientific notation, what is the charge, in coulombs, remaining in the capacitor after 16 seconds?

ANSWER: 1.1 times 10^-6 [SO]

TOSSUP

4) Earth and Space – *Short Answer* Relativistic jets from active galactic nuclei often seem to be moving faster than the speed of light from our reference frame. What term is given to this phenomenon?

ANSWER: Superluminal motion [PB]

BONUS

4) Earth and Space – *Multiple Choice* A region of air has an environmental lapse rate E, a dry adiabatic lapse rate D, and an air parcel that is X degrees warmer than its surroundings. Which of the following equations gives the lifting condensation level, the altitude at which clouds start to form?

W) (D-E)/X [the fraction with numerator D minus E and denominator X]
X) (E-D)/X [the fraction with numerator E minus D and denominator X]
Y) X/(D-E) [the fraction with numerator X and denominator D minus E]
Z) X/(E-D) [the fraction with numerator X and denominator E minus D]

ANSWER: Z) X/(E-D) [PB]

TOSSUP

5) Math – *Multiple Choice* Which of the following conditions is sufficient for a N by N Vandermonde matrix to be invertible for a list of N integers?
W) The integers have a nonzero sum
X) The integers are all nonzero
Y) The sum of the Nth powers of the integers is nonzero
Z) The integers are distinct

ANSWER: Z) The integers are distinct [RG]

BONUS

5) Math – *Short Answer* A perfect number is a number which has the sum of its proper factors equal to itself. Identify all of the following 3 properties that must be true for an odd number to be a perfect number.

1) It must be a perfect square.

2) It must be a perfect square times a prime number.

3) It cannot be a semiprime.

ANSWER: 2 and 3 [RG]

TOSSUP

6) Biology – *Multiple Choice* Which of the following best describes the muscle types found in nematodes, which exhibit a characteristic head-to-tail thrashing motion and no peristalsis?

W) only circular

X) only longitudinal

Y) both circular and longitudinal

Z) neither circular nor longitudinal

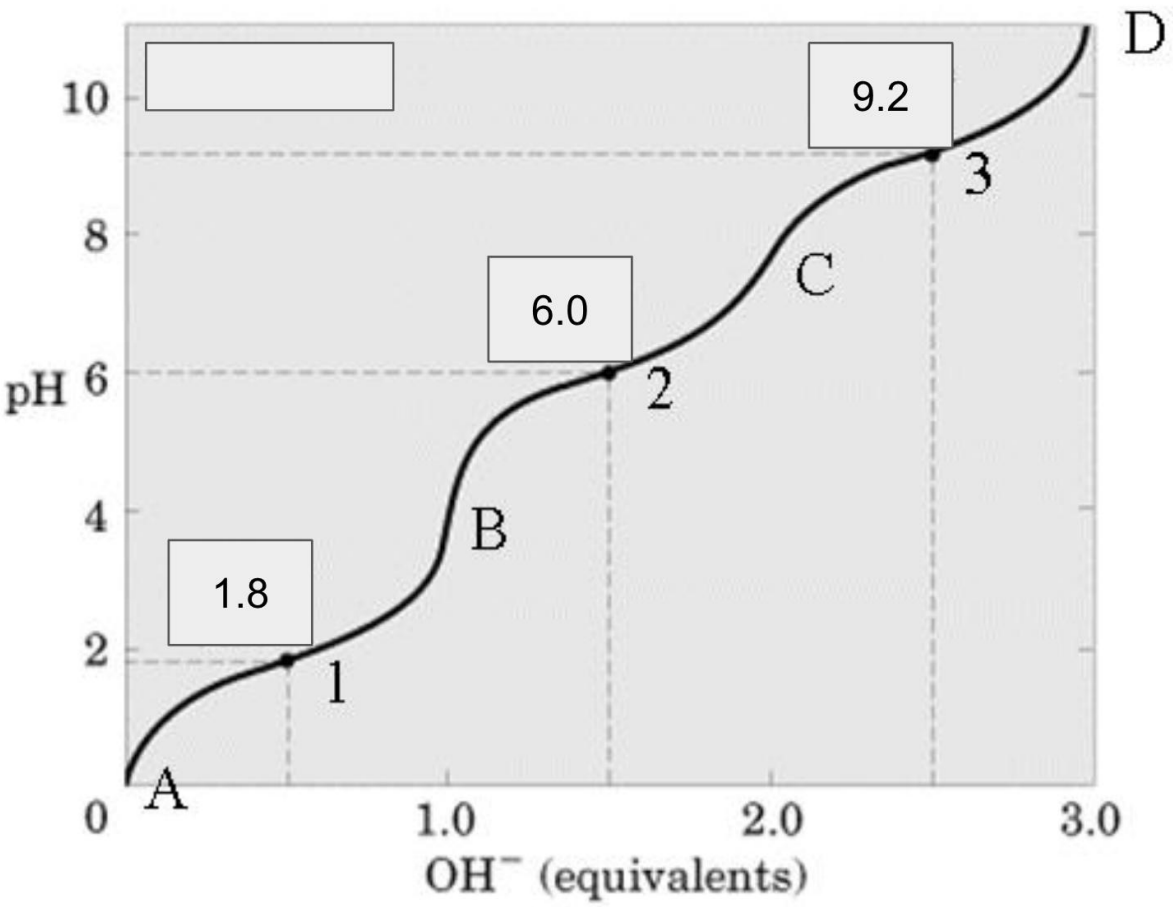
ANSWER: X) ONLY LONGITUDINAL [SO]

VISUAL BONUS

6) Biology – *Short Answer* An unknown amino acid is titrated to create the titration curve shown. When run through an affinity assay, the amino acid's side chain has a high affinity to Ni^{2+} and Co^{2+}. Answer the following two questions:

1. What is the name of this amino acid?

2. Giving your answer to two decimal places, what is the isoelectric point of this amino acid?



ANSWER: HISTIDINE, 7.6 [SO]

TOSSUP

7) Chemistry – *Multiple Choice* Which of the following best compares the envelope conformer of cyclopentane to the planar conformer?

W) More angle strain, more torsional strain

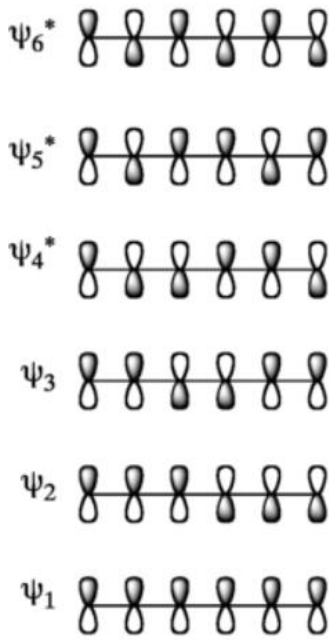
X) More angle strain, less torsional strain

Y) Less angle strain, more torsional strain

Z) Less angle strain, less torsional strain

ANSWER: X) More angle strain, less torsional strain [CZ]

VISUAL BONUS



7) Chemistry – *Short Answer* The following diagram shows the molecular orbitals of 1,3,5-hexatriene. Answer the following two prompts:

1. What is the bond order of the psi-2 molecular orbital?
2. Select all of the following three properties that are higher in 1,3,5-hexatriene than 1,3-butadiene:

A) Energy of light absorbed

B) Reactivity with electrophiles

C) LUMO energy

ANSWER: 1) 3 2) B only [CZ]

TOSSUP

8) Physics – *Short Answer* According to the multipole expansion, the electric potential due to an octopole is proportional to what power of the distance from the center?

ANSWER: -4 [DL]

BONUS

8) Physics – *Short Answer* The energy of a particle in a 2D rectangular box of length 1 meter and width 3 meters at its ground state is E. In terms of E, what is the energy of an identical ground-state particle in a 2D square box of side length 3 meters?

ANSWER: E/5 [DL]

TOSSUP

9) Earth and Space – *Multiple Choice* Which of the following would cause eustatic sea level rise?
W) faster rates of seafloor spreading
X) mountainous erosion
Y) delamination of the crust
Z) formation of glaciers

ANSWER: W) faster rates of seafloor spreading [SO]

BONUS

9) Earth and Space – *Short Answer* Order the following three planets from lowest to highest deuterium to hydrogen ratio in their atmospheres: 1) Earth; 2) Venus; 3) Saturn.

ANSWER: 312 [PB]

TOSSUP

10) Math – *Short Answer* Although the function sending a complex number z to its conjugate is not differentiable, it is however differentiable with respect to the conjugate of z. Therefore, the conjugation function can be described by what term, which means that the function is differentiable at every point in the domain with respect to the conjugate of z?

ANSWER: Antiholomorphic (DO NOT ACCEPT: holomorphic) [RG]

BONUS

10) Math – *Short Answer* Darinah has a 4 by 4 grid. In each cell, she can choose to place an ant or not. How many ways can she do this such that any ant in the grid either has a filled row or a filled column?

ANSWER: 226 [RG]