2024 SMH Invitational Cup - DOUBLE ELIMINATION 1

TOSSUP

1) Biology – *Multiple Choice* A patient presents with unusually high urine volume and dehydration. Suspecting diabetes mellitus, a doctor advised reduction of sugar intake, but no effect was seen on the patient's diuresis. A deficiency of which of the following hormones would the doctor most likely suspect to be causing the patient's condition?
W) ADH
X) ANP
Y) TSH
Z) LH

ANSWER: W) ADH [SO]

BONUS

1) Biology – *Short Answer* Identify all of the following three ions that could be obtained by a plant secreting organic acids into the soil.
I. magnesium
II. chloride
III. nitrate

ANSWER: I only [SO]

TOSSUP

2) Chemistry – *Multiple Choice* Which of the following hypervalent compounds has an octahedral electron pair geometry?

W) sulfur hexafluoride
X) chlorine trifluoride
Y) triiodide ion
Z) phosphorus pentafluoride

ANSWER: W. sulfur hexafluoride [DL]

BONUS

2) Chemistry – *Short Answer* Rank the following 3 cycloalkanes by increasing ring strain.
1) Cyclobutane
2) Cyclopentane
3) Cyclohexane

ANSWER: 321 [CZ]

TOSSUP

3) Physics – *Short Answer* Identify all of the following 3 values which are non-zero for a photon: 1) mass, 2) momentum, 3) spin.

ANSWER: 2 and 3 [SO]

BONUS

3) Physics – *Multiple Choice* A proton is given an initial velocity in the positive x-direction in a region with a magnetic field in the positive y-direction, and starts to trace out a circular path with radius R. If an electron is given an identical initial velocity in the same magnetic field, which of the following best describes the direction of initial acceleration and radius of path, respectively, of the electron?
W) positive z, less than R
X) negative z, less than R
Y) positive z, greater than R
Z) negative z, greater than R

ANSWER: X) negative z, less than R [SO]

TOSSUP

4) Earth and Space – *Short Answer* Identify all of the following three elements that are considered metals in stellar astronomy: 1) lithium; 2) boron; 3) oxygen.

ANSWER: All [PB]

BONUS

4) Earth and Space – *Short Answer* Diamond, which commonly forms octahedral crystals, has how many planes of cleavage?

ANSWER: 4 [SO]

TOSSUP

5) Math – *Multiple Choice* Given that 496 is a perfect number, which of the following is the sum of the factors of 496?
W) 496
X) 744
Y) 992
Z) 1488

ANSWER: Y) 992 [RG]

BONUS

5) Math – *Short Answer* Over its entire domain, what is the minimum value of the function f(x) = x^4 - 4x^2?

ANSWER: -4 [RG]

TOSSUP

6) Biology – *Short Answer* Hemichannels and connexins are associated with what class of mammalian cell junction, which are found in intercalated discs and allow ion transport between cells?

ANSWER: gap junction [SO]

BONUS

6) Biology – *Multiple Choice* Which of the following processes does not occur in the nucleolus?
W) rRNA transcription
X) ribosomal protein translation
Y) assembly of 40s ribosomal subunit
Z) rDNA organization

ANSWER: X) RIBOSOMAL PROTEIN TRANSLATION [SO]

TOSSUP

7) Chemistry – *Multiple Choice* Lanthanide contraction, responsible for similar sizes of 4d and 5d transition metals, is caused by poor shielding from which subshell?
W) 4f
X) 5f
Y) 3d
Z) 4s

ANSWER: W) 4f [CZ]

BONUS

7) Chemistry – *Multiple Choice* Silicon is widely used in computer chips as a semiconductor. Which of the following elements displays similar properties?
W) Beryllium
X) Boron
Y) Carbon
Z) Nitrogen

ANSWER: X) Boron [CZ]

TOSSUP

8) Physics – *Short Answer* The maximum potential achievable by a Van de Graaf generator is in part determined by the characteristics of the air surrounding it. What process, where an insulator subjected to a high voltage becomes a conductor, prevents Van de Graaf generators from amassing indefinitely large amounts of charge?

ANSWER: dielectric breakdown (ACCEPT: electrical breakdown) [SO]

BONUS

8) Physics – *Short Answer* In a certain medium, what quantity represents the ratio between the optical path length and the geometric path length?

ANSWER: index of refraction [DL]

TOSSUP

9) Earth and Space – *Multiple Choice* Spherules and tektites are examples of which of the following types of marine sediment?
W) lithogenous
X) biogenous
Y) hydrogenous
Z) cosmogenous

ANSWER: Z) cosmogenous [SO]

BONUS

9) Earth and Space – *Short Answer* Order the following 3 main rings of Saturn from closest to farthest from Saturn:

1. A Ring
2. B Ring
3. C Ring

ANSWER: 321 [DL]

TOSSUP

10) Math – *Multiple Choice* Which of the following is the integral from -1 to 7 of the absolute value of x dx?
W) 24
X) 25
Y) 28
Z) 32

ANSWER: X) 25 [RG]

BONUS

10) Math – *Short Answer* In how many ways can you choose a subset of 3 positive integers from the first 6 positive integers such that the subset contains at least 1 element between 1 and 3 inclusive and at least one element between 4 and 6 inclusive?

ANSWER: 18 [RG]

TOSSUP

11) Biology – *Multiple Choice* Which of the following is closest to the proportion of glucose in human filtrate that is reabsorbed by the kidney?
W) 25%
X) 50%
Y) 75%
Z) 100%

ANSWER: Z) 100% [SO]

BONUS

11) Biology – *Short Answer* Name all of the following three stages of meiosis where sister chromatid cohesion is present only at centromeres.
I) Prophase I
II) Telophase I
III) Metaphase II

ANSWER: II and III [SO]

TOSSUP

12) Chemistry – *Multiple Choice* How many transition states does the SN2 reaction mechanism have?
W) 1
X) 2
Y) 3
Z) 4

ANSWER: W) 1 [CZ]

BONUS

12) Chemistry – *Multiple Choice* Which of the following is closest to the pH of a solution with a 1 times 10^-9 molar concentration of sodium hydroxide?

W) 5
X) 7
Y) 9
Z) 11

ANSWER: X) 7 [CZ]

TOSSUP

13) Physics – *Multiple Choice* Which of the following is not a correct unit for energy?
W) newton-meter
X) volt-coulomb
Y) tesla-meter per second
Z) kilogram-meters squared per seconds squared

ANSWER: Y) tesla-meter per second [SO]

BONUS

13) Physics – *Short Answer* Connor, an avid bicyclist, is approaching the top of a hill, which can be approximated at the peak as a circle with radius 5 meters. If Connor intends to leap off the hill like a stuntman, then in meters per second and to one significant figure, what is the minimum velocity he needs as he approaches the top of the hill?

ANSWER: 7 [SO]

TOSSUP

14) Earth and Space – *Short Answer* The blue color of the sky is primarily due to what type of scattering in normal air?

ANSWER: Rayleigh scattering [PB]

BONUS

14) Earth and Space – *Short Answer* Order the following three types of spiral galaxies in terms of increasing definition of spiral arms: 1) Flocculent; 2) Grand design; 3) Multi-armed.

ANSWER: 132 [PB]

TOSSUP

15) Math – *Short Answer* Point A is the center of a circle. Points B and C are randomly chosen inside the circle. What is the probability that angle BAC is obtuse?

ANSWER: 1/2 [RG]

BONUS

15) Math – *Short Answer* How many digits does 20 raised to the 24th power have?

ANSWER: 32 [RG]

TOSSUP

16) Biology – *Short Answer* Identify all of the following three types of RNA which can induce formation of heterochromatin.
I. tRNA
II. siRNA
III. piRNA

ANSWER: II AND III [SO]

BONUS

16) Biology – *Short Answer* What polyploid hematopoietic cells give rise to platelets?

ANSWER: megakaryocytes [SO]

TOSSUP

17) Chemistry – *Short Answer* The compound $TlCl_3$ is rarely found. Instead, thallium tends to form compounds with a +1 oxidation state due to what effect?

ANSWER: inert pair effect [CZ]

BONUS

17) Chemistry – *Multiple Choice* Which of the following oxides exhibits acidic properties when dissolved in a basic aqueous solution?
W) BaO
X) CaO
Y) MgO
Z) BeO

ANSWER: Z) BeO [CZ]

TOSSUP

18) Physics – *Short Answer* When cooled down to very low temperatures, what state of matter does helium-3 enter, which does not dissipate energy through friction between individual atoms?

ANSWER: SUPERFLUID [SO]

BONUS

18) Physics – *Short Answer* An ideal massless spring with spring constant 12 newtons per meter is initially compressed 4 meters from equilibrium. It is released and used to launch a ball towards another ideal massless spring with spring constant 3 newtons per meter, which is initially at rest. What is the maximum compression of the second spring?

ANSWER: 8 [SO]

TOSSUP

19) Earth and Space – *Multiple Choice* At which of the following locations would the Coriolis effect be strongest?
W) Reykjavik, Iceland
X) the Everglades, Florida
Y) Rio de Janeiro, Brazil
Z) Beijing, China

ANSWER: W) Reykjavik, Iceland [SO]

BONUS

19) Earth and Space – *Short Answer* Identify all of the following three geological features which are aeolian in nature: 1) yardangs, 2) moraines, 3) eskers.

ANSWER: 1 ONLY [SO]

TOSSUP

20) Math – *Multiple Choice* A piece of information about a triangle is the measure of one of the 3 angles or the length of one of the 3 sides. If you are given 3 distinct pieces of information about a triangle, which of the following best describes the number of possible triangles that fit the criteria?
W) 0 and 1
X) 1 and 2
Y) 0 and 2
Z) 0, 1, and 2

ANSWER: Z) 0, 1, and 2 [RG]

BONUS

20) Math – *Short Answer* Ritwik is trying to find the critical points of a function and he knows that one such critical point exists on the interval [0,2] by applying Rolle's theorem. Identify all of the following functions he could be looking at.
1) f(x) = x^2 - 1
2) f(x) = (x-1)^2
3) f(x) = x^3 - 4x

ANSWER: 2 and 3 [RG]
