2024 SMH Invitational Cup - DOUBLE ELIMINATION 3

TOSSUP

1) Biology – *Short Answer* After a certain range, auxin stops inducing shoot growth and instead inhibits cell elongation. This is through an increase in the production of what other plant hormone?

ANSWER: ETHYLENE [SO]

BONUS

1) Biology – *Short Answer* Identify all of the following three bacteria which will stain pink after a Gram stain.
I. M. leprae
II. B. aureus
III. E. coli

ANSWER: III only [SO]

TOSSUP

2) Chemistry – *Multiple Choice* Connor is attempting to freeze water, but he is extremely unskilled and instead supercools the water. Which of the following best describes the enthalpy and entropy change when his supercooled water finally freezes?
W) Positive delta H, positive delta S
X) Positive delta H, negative delta S
Y) Negative delta H, positive delta S
Z) Negative delta H, negative delta S

ANSWER: Z) Negative delta H, negative delta S [CZ]

BONUS

2) Chemistry – *Short Answer* How many total valence electrons are present in one molecule of aniline, with formula C6H5NH2?

ANSWER: 36 [CZ]

TOSSUP

3) Physics – *Multiple Choice* Two point charges of charge +Q are held at rest very close to each other in a frictionless void. At time t = 0, the charges are released. Which of the following describes the speed of either charge in the lab frame after a long time has passed?
W) approaches 0
X) approaches a non-zero constant
Y) approaches infinity
Z) approaches the speed of light

ANSWER: X) approaches a non-zero constant [SO]

BONUS

3) Physics – *Short Answer* What set of partial differential equations describe the flows of viscous fluids by applying Newton's second law?

ANSWER: Navier-Stokes equations [SO]

TOSSUP

4) Earth and Space – *Multiple Choice* Which of the following minerals would you expect to form alongside sphalerite in volcanogenic massive sulfide ore deposits?

W) Corundum
X) Malachite
Y) Pyrolusite
Z) Galena

ANSWER: Z) Galena [AS]

BONUS

4) Earth and Space – *Short Answer* Star A, which has temperature T and radius R, has a peak wavelength of x. If Star B has temperature T and radius 4R, then in terms of x, what is the peak wavelength of Star B?

ANSWER: x [AS]

TOSSUP

5) Math – *Multiple Choice* As N approaches infinity, the ratio between the N+2 th fibonacci number to the Nth fibonacci number approaches which of the following?
W) (1+sqrt5)/2
X) (sqrt5-1)/2
Y) (3+sqrt5)/2
Z) (3+2sqrt5)/2

ANSWER: Y) (3+sqrt5)/2 [RG]

BONUS

5) Math – *Short Answer* Daniel has rods of length 3, 5, and 7, such that he has 3 rods of each length. How many distinct triangles can he make with these 3 rods?

ANSWER: 9 [RG]

TOSSUP

6) Biology – *Multiple Choice* Which immunoglobulin isotype is found in a pentameric form?
W) IgA
X) IgD
Y) IgE
Z) IgM

ANSWER: Z) IgM [SO]

BONUS

6) Biology – *Short Answer* Alex and James, both healthy adults, are worried about the risk of their child inheriting cystic fibrosis. James knows that he is a carrier, while Alex's brother died from the disease. If Alex's parents are both unaffected by cystic fibrosis, what is the probability that Alex and James' child inherits the disorder?

ANSWER: 1/6 [SO]

TOSSUP

7) Chemistry – *Multiple Choice* Sacrificial anodes are commonly used to protect large metal objects. Which of the following metals is most commonly used as a sacrificial anode?
W) Iron
X) Aluminum
Y) Silver
Z) Zinc

ANSWER: Z) Zinc [CZ]

BONUS

7) Chemistry – *Multiple Choice* Solutions of which of the following salts would absorb light at the highest frequency?
W) Potassium permanganate
X) Copper (II) sulfate
Y) Sodium dichromate
Z) Iron (III) chloride

ANSWER: Y) Sodium dichromate [CZ]

TOSSUP

8) Physics – *Multiple Choice* Ava is exhausted after a performance and collapses onto a rocking chair, setting it into oscillation. However, over multiple oscillations the rocking chair slowly comes to a stop. Which of the following best describes these oscillations?
W. Simple harmonic
X. Underdamped
Y. Critically damped
Z. Overdamped

ANSWER: X. Underdamped [DL]

BONUS

8) Physics – *Short Answer* Identify all of the following three wavelengths of light that display significant diffraction effects after passing through a thin slit of width 0.5 nanometers.
1. Visible light
2. X-rays
3. Radio waves

ANSWER: 2 only [DL]

TOSSUP

9) Earth and Space – *Short Answer* Identify all of the following 4 Galilean moons that are tidally locked with Jupiter:

1. Io
2. Europa
3. Ganymede
4. Callisto

ANSWER: all [DL]

BONUS

9) Earth and Space – *Short Answer* Identify all of the following three conditions which would lead to upwelling: 1) wind blowing south along western US coast, 2) wind blowing south along eastern US coast, 3) wind blowing south along western coast of Chile.

ANSWER: 1 ONLY [SO]

TOSSUP

10) Math – *Short Answer* What statement, when combined with Zorn's lemma, is equivalent to the axiom of choice, asserts that any set of nonnegative integers has a least element?

ANSWER: Well-ordering principle [RG]

BONUS

10) Math – *Short Answer* Trapezoid ABCD has parallel bases AB and CD. Both angle ADC and BCD are acute. The length of AD is 15 and the length of BC is 20. If the height is 12 and the area is 258, what is the length of the shorter base?

ANSWER: 9 [RG]

TOSSUP

11) Biology – *Multiple Choice* Which of the following is nearest to the pH of human skin?
W) 4
X) 6
Y) 8
Z) 10

ANSWER: W) 4 [SO]

BONUS

11) Biology – *Multiple Choice* The species richness of open ocean ecosystems is relatively low compared to terrestrial ecosystems. Which of the following best explains this phenomenon?
W) competitive exclusion principle
X) intermediate disturbance hypothesis
Y) Allee effect
Z) character displacement

ANSWER: X) intermediate disturbance hypothesis [SO]

TOSSUP

12) Chemistry – *Short Answer* Scientists are attempting to use density functional theory to simulate molecules. The energy level of the highest occupied molecular orbital of a system is equal to negative one times what quantity?

ANSWER: ionization energy [CZ]

BONUS

12) Chemistry – *Short Answer* Name all of the following nitrogen compounds that are paramagnetic:
1) NO
2) N2O
3) NO2

ANSWER: 13 [CZ]

TOSSUP

13) Physics – *Multiple Choice* Adeline is measuring the speed of sound in a certain fluid. The speed of sound is proportional to what power of the density of the fluid?
W) -2
X) -1/2
Y) 1/2
Z) 2

ANSWER: X) -1/2 [SO]

BONUS

13) Physics – *Short Answer* Under certain conditions, inhomogeneous pair production from vacuum fluctuations may induce small net forces. This leads to what effect, which was first experimentally demonstrated with a pair of parallel plates?

ANSWER: Casimir effect [DL]

TOSSUP

14) Earth and Space – *Multiple Choice* Which of the following sedimentary rocks is NOT composed of calcium carbonate?

W) Chert
X) Coquina
Y) Travertine
Z) Tufa

ANSWER: W) Chert [PB]

BONUS

14) Earth and Space – *Short Answer* Identify all of the following three tectonic plates that are separated from the Pacific plate by a convergent boundary: 1) Cocos; 2) Juan de Fuca; 3) Nazca.

ANSWER: None [PB]

TOSSUP

15) Math – *Short Answer* An arithmetic sequence has first term 7 and has a common difference of 8. For each term, Kian computes the minimum number of perfect squares that need to be added together to yield that term. Over all terms, what is the minimum value Kian computed?

ANSWER: 4 [RG]

BONUS

15) Math – *Short Answer* How many 3-digit positive integers have the product of their digits equal to 24?

ANSWER: 21 [RG]

TOSSUP

16) Biology – *Multiple Choice* A marine biologist is studying animals in the class Scyphozoa. Which of the following groups is this biologist studying?
W) whales
X) jellies
Y) lampreys
Z) corals

ANSWER: X) JELLIES [SO]

BONUS

16) Biology – *Short Answer* Individuals with the Bombay blood group cannot produce the AB surface antigens due to being homozygous recessive for the transferase enzyme FUT1, which acts on modified serine residues. Knowing the structure of blood antigens, what organelle is FUT1 most likely located in?

ANSWER: GOLGI APPARATUS [SO]

TOSSUP

17) Chemistry – *Short Answer* Methyllithium, a common organic reagent used to reduce carbonyl groups, must be used in aprotic solvents. If water is used as a solvent with methyllithium, what undesirable organic molecule is formed instead?

ANSWER: Methane [CZ]

BONUS

17) Chemistry – *Short Answer* What theorem states that each degree of freedom of a molecule contributes equally to its energy?

ANSWER: equipartition theorem [CZ]

TOSSUP

18) Physics – *Short Answer* What quantity, whose integral over time is action, is the basis for its namesake mechanics and is obtained by subtracting potential energy from kinetic energy?

ANSWER: Lagrangian [DL]

BONUS

18) Physics – *Short Answer* A 10 kilogram cat is riding a 20 kilogram sled on frictionless ice at an initial speed of 5 meters per second. The cat then jumps off the sled in the initial direction of motion with relative velocity 3 meters per second with respect to the sled. In meters per second, what is the velocity of the sled with respect to the Earth after the cat jumps off?

ANSWER: 4 [SO]

TOSSUP

19) Earth and Space – *Multiple Choice* A Yerkes spectral classification of 1a indicates that a star is part of which of the following groups?
W) Dwarfs
X) Main sequence
Y) Giants
Z) Supergiants

ANSWER: Z) Supergiants [PB]

BONUS

19) Earth and Space – *Multiple Choice* Lake-effect snow most commonly causes increased snowfall in which cardinal direction relative to the Great Lakes?
W) North
X) South
Y) East
Z) West

ANSWER: Y) East [PB]

TOSSUP

20) Math – *Multiple Choice* Ryan is trying to approximate the area under the curve of y = x^2 from -3 to 3. He first uses 6 left endpoint rectangles with base 1 and then uses 6 trapezoids with base 1. Which of the following describes his approximations for the area using the left endpoint rectangles and the trapezoids, respectively?
W) Overestimate, overestimate
X) Overestimate, underestimate
Y) Underestimate, overestimate
Z) Underestimate, underestimate

ANSWER: W) Overestimate, overestimate [RG]

BONUS

20) Math – *Short Answer* An infinite geometric series has first term 8 and third term 4. What is the sum of the elements in the series?

ANSWER: 16 + 8sqrt2 [RG]
