2024 SMH Invitational Cup - DOUBLE ELIMINATION 5

TOSSUP

1) Biology – *Multiple Choice* The reabsorption of bicarbonate in the kidneys can take place via the metabolism of what amino acid, which forms ammonium that is then excreted in the urine?
W) alanine
X) glutamine
Y) cysteine
Z) methionine

ANSWER: X) GLUTAMINE [SO]

BONUS

1) Biology – *Short Answer* Name all of the following three hormones that are responsible for the degeneration of female reproductive ducts and the formation of male reproductive ducts.
I. Anti-Müllerian hormone
II. Luteinizing hormone
III. Testosterone

ANSWER: I and III [SO]

TOSSUP

2) Chemistry – *Multiple Choice* Which of the following ligands will cause the most d orbital splitting?
W) CO
X) H_2O
Y) Cl^-
Z) OH^-

ANSWER: W) CO [CZ]

BONUS

2) Chemistry – *Short Answer* Name all of the following three properties of a solution that must remain additive when two non-ideal solutions are mixed:
1) Molality
2) Entropy
3) Vapor pressure

ANSWER: 1 [CZ]

TOSSUP

3) Physics – *Multiple Choice* A block with mass m lies at rest on an inclined plane angled at theta degrees above the horizontal and with coefficient of friction mu. Which of the following expressions best describes the magnitude of the frictional force on the block?
W) mg cosine theta
X) mg sine theta
Y) mu mg cosine theta
Z) mu mg sine theta

ANSWER: X) mg sine theta [SO]

BONUS

3) Physics – *Short Answer* Consider a long segment of an axon, which can be modeled as a cylindrical shell of phospholipid bilayer. Assuming that the separation between the bilayers is much less than the radius of the cylinder, to what power of radius and what power of the thickness of the bilayer, respectively, is the capacitance of the axon proportional?

ANSWER: 1, -1 [BC]

TOSSUP

4) Earth and Space – *Multiple Choice* Northern Russia and Canada are dominated by which of the following soil orders?

W) Alfisols
X) Gelisols
Y) Inceptisols
Z) Mollisols

ANSWER: X) Gelisols [PB]

BONUS

4) Earth and Space – *Short Answer* Identify all of the following three protostar masses, in solar masses, that would follow the Hayashi track during their early evolution: 1) 1; 2) 2; 3) 0.5.

ANSWER: All [PB]

TOSSUP

5) Math – *Multiple Choice* Which of the following must be true about abelian groups but is not true about all other groups?
W) The operation is commutative
X) The operation is associative
Y) The operation is distributive
Z) The operation has an identity element

ANSWER: W) The operation is commutative [RG]

BONUS

5) Math – *Short Answer* For how many distinct integers n is (x^2-7x+11)^(x^2-2x) (*read*: open parenthesis x squared minus 7x plus 11 close parenthesis to the power of open parenthesis x squared minus 2x close parenthesis) equal to 1?

ANSWER: 4 [RG]

TOSSUP

6) Biology – *Short Answer* Identify all of the following three sex determination systems in which males and females have the same number of chromosomes: 1) ZW, 2) XO, 3) haplodiploid.

ANSWER: 1 ONLY [SO]

BONUS

6) Biology – *Short Answer* Adeline conducts a cross between an individual who is heterozygous for 3 genes and an individual who is homozygous recessive for all 3 genes. Giving your answer as a fraction in simplest form, what is the chance that the resulting offspring displays exactly 2 dominant phenotypes and 1 recessive phenotype?

ANSWER: 3/8 [SO]

TOSSUP

7) Chemistry – *Multiple Choice* Which of the following best describes the formation of the Hofmann product in elimination?
W) higher activation energy, higher final energy

X) higher activation energy, lower final energy
Y) lower activation energy, higher final energy
Z) lower activation energy, lower final energy

ANSWER: Y) lower activation energy, higher final energy [CZ]

BONUS

7) Chemistry – *Multiple Choice* Which of the following alkanes has the single weakest carbon-hydrogen bond?
W) methane
X) isobutane
Y) propane
Z) ethane

ANSWER: X) isobutane [CZ]

TOSSUP

8) Physics – *Short Answer* In superconductors, the London penetration depth describes the distance it takes for the magnetic field to drop to how many times its value at the surface?

ANSWER: 1/e [CZ]

BONUS

8) Physics – *Multiple Choice* Which of the following, in degrees, is closest to the angle of the Mach cone of an object with a speed of Mach 2?

W. 30
X. 45
Y. 60

Z. 75

ANSWER: W. 30 [DL]

TOSSUP

9) Earth and Space – *Multiple Choice* Which of the following best describes the nutrient levels and oxygen concentrations, respectively, in oligotrophic lakes?
W) high, high
X) high, low
Y) low, high
Z) low, low

ANSWER: Y) low, high [SO]

BONUS

9) Earth and Space – *Short Answer* An asteroid orbits the Sun in an elliptical orbit with semimajor axis 13 AU and semiminor axis 12 AU. In AU, what is the difference between the asteroid's distance from the Sun at its aphelion and perihelion?

ANSWER: 10 [PB]

TOSSUP

10) Math – *Short Answer* Identify all of the following 3 shapes that can be uniquely defined by 3 points on the edge of the shape:
1) Circle
2) Parabola
3) Ellipse

ANSWER: 1, 2 [RG]

BONUS

10) Math – *Short Answer* Triangle ABC satisfies AB = 13, BC = 14, and AC = 15. If P is chosen on the segment BC, how many distinct integers values can the length of segment AP take?

ANSWER: 4 [RG]

TOSSUP

11) Biology – *Short Answer* What valve-like structure controls water flow into the water vascular system of echinoderms?

ANSWER: MADREPORITE [SO]

BONUS

11) Biology – *Short Answer* An animal cell is currently in metaphase. Order the following three events from first to last to occur in this cell as a consequence of mitosis: 1) start of actin polymerization, 2) start of tubulin depolymerization, 3) start of lamin polymerization.

ANSWER: 213 [SO]

TOSSUP

12) Chemistry – *Multiple Choice* How many distinct bond lengths are there in SOF4?
W) 2
X) 3

Y) 4
Z) 5

ANSWER: X) 3 [CZ]

BONUS

12) Chemistry – *Multiple Choice* Alkenes commonly act as nucleophiles in addition reactions. Which of the following properties explains the electrophilicity of the Br2 molecule?
W) Low energy HOMO
X) Low energy LUMO
Y) High energy HOMO
Z) High energy LUMO

ANSWER: X) Low energy LUMO [CZ]

TOSSUP

13) Physics – *Multiple Choice* A rocket propels itself by ejecting a constant amount of fuel per unit time at a constant velocity relative to itself. Which of the following best describes the magnitude of the force experienced by the rocket and the acceleration of the rocket as a function of time, respectively?
W) increasing, increasing
X) increasing, constant
Y) constant, increasing
Z) constant, constant

ANSWER: Y) constant, increasing [SO]

BONUS

13) Physics – *Short Answer* What relativistic wave equation describes all massive particles with half-integer spin?

ANSWER: Dirac Equation [DL]

TOSSUP

14) Earth and Space – *Short Answer* According to the virial theorem, what is the ratio of the magnitude of an orbiting body's kinetic energy to the magnitude of its potential energy?

ANSWER: 1:2 (ACCEPT: 1/2) [PB]

BONUS

14) Earth and Space – *Multiple Choice* Which of the following best describes how the altitude of upper-level pressure isobars changes from the equator to the poles?

W) Uniformly increases
X) Uniformly decreases
Y) Increases, then decreases
Z) Decreases, then increases

ANSWER: X) Uniformly decreases [PB]

TOSSUP

15) Math – *Short Answer* The gamma function is an extension of the factorial function to any real number input. What is the value of the gamma function at x = 5?

ANSWER: 24 [RG]

BONUS

15) Math – *Short Answer* Suzuko is given the following system of two congruences: x is congruent to y modulo 4 and x is congruent to z modulo 6, where y and z are constants. Identify all of the following 4 numbers that could be the number of positive integers x less than 24 that satisfy these congruences: 0, 1, 2, 3.

ANSWER: 0, 1, 2 [RG]

TOSSUP

16) Biology – *Multiple Choice* Phoebe is playing around with a solution of an unknown chemical. When she tests the solution using Tollen's reagent, she notices a silver mirror forming on the surface of her test tube. Which of the following chemicals could be the chemical in Phoebe's solution?
W) sucrose
X) cholesterol
Y) glucose
Z) albumin

ANSWER: Y) glucose [SO]

BONUS

16) Biology – *Short Answer* Identify all of the following three statements that are true regarding phytochromes.
I. higher proportions of Pfr induce lateral branching
II. Pr is slowly degraded by enzymes
III. phytochromes are covalently bonded to bile pigments

ANSWER: I AND III [SO]

TOSSUP

17) Chemistry – *Multiple Choice* Which of the following acids is strongest in glacial acetic acid?

W) HCl

X) H_2SO_4

Y) $HClO_4$

Z) HNO_3

ANSWER: Y) $HClO_4$ [CZ]

BONUS

17) Chemistry – *Short Answer* (note: read formulas slowly) Name all of the following 3 molecules that can be described by 3-center-4-electron bonding:

1) Al_2Cl_6

2) SF_4

3) XeF_2

ANSWER: all [CZ]

TOSSUP

18) Physics – *Multiple Choice* Heat transfer through conduction is facilitated by what quasiparticle?

W) exciton

X) polaron

Y) phonon

Z) electron hole

ANSWER: Y) phonon [CZ]

BONUS

18) Physics – *Short Answer* A ray of light passes through vacuum and enters another medium. Identify all of the following three degree measures that could be the value of Brewster's angle at the interface: 1) 30, 2) 40, 3) 50.

ANSWER: 3 only [SO]

TOSSUP

19) Earth and Space – *Multiple Choice* Assuming the protolith was mafic in origin, grains of chlorite and muscovite would most likely be found in which of the following rocks?
W) Shale
X) Phyllite
Y) Schist
Z) Gneiss

ANSWER: X) Phyllite [PB]

BONUS

19) Earth and Space – *Multiple Choice* While scrolling google, Edwin encounters an image of the Orion nebula. He notices there are 6 equally spaced diffraction spikes around each star. Which of the following telescopes could have taken the image that Edwin is looking at?

W. WISE
X. JWST
Y. Hubble
Z. Spitzer

ANSWER: X. JWST [AS]

TOSSUP

20) Math – *Short Answer* Let x, y, and z be positive real numbers such that x^2 times y times z is equal to 324. What is the minimum possible value of x + y + z?

ANSWER: 12 [RG]

BONUS

20) Math – *Short Answer* The first 3 terms in a geometric series have product 1728 and sum 48. If the common ratio is squared, and the 2nd term of the series stays the same, what is the new sum of the first 3 elements?

ANSWER: 96 [RG]
