CENTENNIAL AUTUMN SCIENCE TOURNAMENT - ROUND 7

TOSS-UP

1) Biology – *Short Answer* What phylum of deuterostomes is generally considered the sister phylum of echinoderms and contains acorn worms?

ANSWER: HEMICHORDATA

BONUS

1) Biology – *Multiple Choice* A sea cucumber can most commonly be classified as which of the following kinds of hermaphrodites?

W) Sequential hermaphrodites
X) Simultaneous hermaphrodites
Y) Bidirectional sex changers
Z) Sea cucumbers are not usually hermaphrodites

ANSWER: Z) SEA CUCUMBERS ARE NOT USUALLY HERMAPHRODITES

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TOSS-UP

2) Chemistry – *Multiple Choice* Which of the following solvents would be the best for use in thin-layer chromatography of benzoic acid?

W) Acetone
X) Ethanol
Y) Hexane
Z) Methylene chloride

ANSWER: X) ETHANOL

BONUS

2) Chemistry – *Short Answer* By name or number, order the following four stationary phases in increasing order of adsorbance in thin-layer chromatography:

1) alumina
2) charcoal
3) florisil
4) silica

ANSWER: SILICA, FLORISIL, CHARCOAL, ALUMINA (ACCEPT: 4, 3, 2, 1)

TOSS-UP
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3) Physics – *Short Answer* A circuit has an infinite number of capacitors in series. If the capacitance of each capacitor is twice the capacitance of the previous, and the first capacitor has capacitance C, what is the equivalent capacitance in the circuit in terms of C?

ANSWER: C/2

BONUS

3) Physics – *Short Answer* A series RLC circuit has a Q-factor of 5. Using the same resistor, inductor, and capacitor, what would the Q-factor be of a parallel RLC circuit if the resistor has resistance 5 ohms?

ANSWER: 1

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TOSS-UP

4) Math – *Multiple Choice* Which of the following statements is true about infinite series?

W) Infinite series must converge if the limit of the sequence approaches zero at infinity
X) If the ratio of consecutive terms approaches 1 at infinity, the sequence diverges
Y) If the difference between consecutive terms does not approach zero, the series must diverge
Z) If a series is divergent, there exists an infinite subsequence that is convergent

ANSWER: Y) IF THE DIFFERENCE BETWEEN CONSECUTIVE TERMS DOES NOT APPROACH ZERO, THE SERIES MUST DIVERGE

BONUS

4) Math – *Short Answer* Evaluate the sum from i = 1 to 35 of $1/(\sqrt{\square + 1} + \sqrt{\square})$

ANSWER: 5
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TOSS-UP

5) Earth and Space – *Multiple Choice* How would lava with 65% silica be classified?

W) Andesitic
X) Felsic
Y) Mafic
Z) Ultrafelsic

ANSWER: X) FELSIC

BONUS

5) Earth and Space – *Multiple Choice* In a volcanic eruption, there was one big explosion and then pyroclastic flows down the side of the volcano. Which of the following most accurately classifies the eruption?

W) Hawaiian
X) Peléan
Y) Plinian
Z) Vulcanian

ANSWER: X) PELÉAN

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TOSS-UP

6) Energy – *Short Answer* Researchers at the University of Chicago are studying the evolutionary biology of plants. During which period did angiosperms evolve?

ANSWER: CRETACEOUS

BONUS

6) Energy – *Multiple Choice* Researchers at Argonne National Lab are studying fossilized plants and plant resins. Which of the following comparisons between copal and amber is correct?

W) Amber has a hardness of around 2.5 on the Mohs scale while copal only has a hardness of 1.5
X) Copal formed early in geologic time than amber
Y) Amber melts faster than copal and gives off a pine-like scent when doing so
Z) Copal floats in saltwater unlike Amber, which sinks, especially if the solution is mixed with some plastic

ANSWER: W) AMBER HAS A HARDNESS OF AROUND 2.5 ON THE MOHS SCALE WHILE COPAL ONLY HAS A HARDNESS OF 1.5
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TOSS-UP

7) Biology – *Multiple Choice* Which of the following does adenine most commonly deaminate into?

W) Uracil
X) Xanthine
Y) Hypoxanthine
Z) Nothing

ANSWER: Y) HYPOXANTHINE

BONUS

7) Biology – *Short Answer* What term describes the structural motif that arises from two strands of DNA being held apart by a strand of RNA?

ANSWER: R-LOOP

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TOSS-UP

8) Chemistry – *Multiple Choice* In IR spectroscopy, free carboxylic acids should hypothetically absorb at around 1760 inverse centimeters. However, most commonly encountered samples of carboxylic acid absorb closer to 1710 inverse centimeters. Which of the following best explains this phenomenon?

W) Most carboxylic acids are part of conjugated pi systems
X) Most carboxylic acids are part of aromatic pi systems
Y) Most carboxylic acids experience significant hydrogen bonding
Z) Most carboxylic acids experience significant interactions with their solvents

ANSWER: Y) MOST CARBOXYLIC ACIDS EXPERIENCE SIGNIFICANT HYDROGEN BONDING

BONUS

8) Chemistry – *Short Answer* One common method of creating proteins from amino acids in the lab is through treatment with dicyclohexylcarbodiimide, or DCC. Along with peptide chains and water, what product is formed when glycine is reacted with DCC?

ANSWER: DICYCLOHEXYLUREA
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TOSS-UP

9) Physics – *Multiple Choice* A pendulum undergoes overdamped harmonic oscillation. Which of the following could describe the displacement graph with respect to time?

W) Exponential
X) Cycloid
Y) Hyperbolic
Z) Sinusoidal

ANSWER: W) EXPONENTIAL

BONUS

9) Physics – *Multiple Choice* Brandon wants to move a heavy mass. Which of the following would decrease the amount of force he needs to exert the most?

W) A fixed pulley pulling with 2 ropes
X) A fixed pulley pulling with 4 ropes
Y) A compound pulley pulling with 2 ropes
Z) A third class lever

ANSWER: Y) A COMPOUND PULLEY PULLING WITH 2 ROPES

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TOSS-UP

10) Math – *Short Answer* By name or number, identify all of the following 3 statements that are true about the taxicab distance: 1) The taxicab distance is always greater than the Euclidean distance; 2) The taxicab distance is always an integer; 3) The taxicab distance is always positive.

ANSWER: NONE

BONUS

10) Math – *Short Answer* A taxicab starts at the origin and moves with equal probability one unit to the left, right, up, or down. What is its expected taxicab distance from the origin after 2 moves?

ANSWER: 3/2
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TOSS-UP

11) Earth and Space – *Multiple Choice* Which of the following is closest to the minimum mass required to undergo a Type II supernova?

W) 2 solar masses
X) 4 solar masses
Y) 6 solar masses
Z) 8 solar masses

ANSWER: Z) 8 SOLAR MASSES

BONUS

11) Earth and Space – *Multiple Choice* The Cygnus Loop is what type of supernova remnant?

W) Shell-like
X) Composite
Y) Mixed morphology
Z) Thermal composite

ANSWER: W) SHELL-LIKE

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TOSS-UP

12) Biology – *Multiple Choice* Which of the following terms best describes strawberry runners?
W) Stolons
X) Corms
Y) Rhizomes
Z) Tubers

ANSWER: W

BONUS

12) Biology – *Short Answer* By name or number, order the following 3 stele types found in vascular plants based on increasing leaf gap abundance: 1) Protostele; 2) Eustele; 3) Siphonostele.

ANSWER: 1, 2, 3
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TOSS-UP

13) Energy – *Short Answer* Researchers at Brookhaven National Lab are studying Lagrangian mechanics. Lagrangian mechanics are fundamentally based on what principle?

ANSWER: PRINCIPLE OF LEAST ACTION

BONUS

13) Energy – *Short Answer* Researchers at Brookhaven National Lab are studying computationally efficient ways to solve the Euler-Lagrange equation. The Euler-Lagrange equation is central to what field of mathematical analysis?

ANSWER: CALCULUS OF VARIATIONS

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TOSS-UP

14) Chemistry – *Short Answer* By name or number, identify all of the following 4 types of bonds which are found in boranes, a general class of compounds with chemical formula BxHy:
1) 2-center 2-electrons; 2) 3-center-2-electrons; 3) Sigma 3-center-4-electrons;
4) Pi 3-center-4-electrons.

ANSWER: 1 AND 2

BONUS

14) Chemistry – *Multiple Choice* Pentaborane 11, with chemical formula B5H11, is classified as which of the following types of borane clusters?

W) Arachno
X) Closo
Y) Hypho
Z) Nido

ANSWER: W) ARACHNO
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TOSS-UP

15) Physics – *Short Answer* By name or number, order the following 3 objects in increasing order by the time it takes to roll down a ramp without slipping if they have the same mass: 1) Disk with radius 2; 2) Sphere with radius 1; 3) Rod with length 4.

ANSWER: 3, 2, 1

BONUS

15) Physics – *Short Answer* The rotational inertia about the z-axis of a uniform rod of mass M and length L set along the x-axis, with one end on the origin, is $\frac{1}{3}*ML^2$. What is the moment of inertia of a rod of mass 3 kg and length 4 meters about an axis parallel to the z-axis passing through the middle of the rod?

ANSWER: 4

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TOSS-UP

16) Math – *Multiple Choice* Which of these statements is FALSE about simple, connected planar graphs?

W) They can be vertex-colored using 5 colors
X) They must not contain the complete graph K_5
Y) The amount of edges is less than or equal to 3 times the amount of vertices
Z) All vertices must have degree less than 6

ANSWER: Z) ALL VERTICES MUST HAVE DEGREE LESS THAN 6

BONUS

16) Math – *Short Answer* How many edges must be removed from K_6, the complete graph on six vertices to leave a graph without any copies of K_4, the complete graph on four vertices?

ANSWER: 3
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TOSS-UP

17) Earth and Space – *Multiple Choice* Which of the following kinds of moraines is the most common?

W) Ground Moraine
X) Lateral Moraine
Y) Medial Moraine
Z) Terminal Moraine

ANSWER: W) GROUND MORAINE

BONUS

17) Earth and Space – *Multiple Choice* Which of the following minerals lacks cleavage?

W) Olivine
X) Epidote
Y) Staurolite
Z) Sodalite

ANSWER: W) OLIVINE

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TOSS-UP

18) Energy – *Short Answer* Researchers at Idaho National Labs are studying how to implement solar energy in the US. By name or number, order the following 4 layers from furthest to exposed sunlight to closest to exposed sunlight in a solar panel: 1) Silicon layer; 2) N type semiconductor; 3) P type.semiconductor.

ANSWER: 3, 1, 2

BONUS

18) Energy – *Short Answer* Researchers at Lawrence Berkeley National Lab are studying how to shorten methane's lifespan in the atmosphere. By name or number, identify all of the following 3 greenhouse gases that have a Global Warming Potential less than that of methane: 1) Water; 2) Carbon Dioxide; 3) Nitrous Oxide.

ANSWER: 1 AND 2
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TOSS-UP

19) Biology – *Multiple Choice* Which of the following animals would produce the highest urine/plasma ratio?

W) Salmon
X) Salamander
Y) Kangaroo rat
Z) Ostrich

ANSWER: Y) KANGAROO RAT

BONUS

19) Biology – *Multiple Choice* Which of the following neurotransmitters mimics the effects of the neurotransmitter glutamate in regards to synaptic plasticity?

W) TRPV1
X) NMDA
Y) P2X
Z) GABA

ANSWER: X) NMDA

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TOSS-UP

20) Chemistry – *Short Answer* By name or number, order the following three measures of speed for a sample of gas particles from least to greatest: 1) Average; 2) Root mean square; 3) Most common.

ANSWER: 3, 1, 2

BONUS

20) Chemistry – *Multiple Choice* Which of the following is closest to the value of X given that half of the particles in a sample of gas are moving at a speed between 0 and X times the square root of the quantity RT over M?

W) 1.4
X) 1.5
Y) 1.6
Z) 1.7

ANSWER: Y) 1.6
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TOSS-UP

21) Physics – *Multiple Choice* Two initially uncharged conductors are mounted on insulating stands. A negatively charged rod is brought near the conductors but does not touch them. With the rod held in place, conductor 2 is moved to the right so that the conductors are separated. What is the charge on conductor 2?

W) Positive
X) Negative
Y) Zero
Z) Indeterminate

ANSWER: X) NEGATIVE

BONUS

21) Physics – *Multiple Choice* A negatively charged rod is brought near, but does not touch, an initially uncharged electroscope. With the rod in place, a finger touches the electroscope. When the finger and the rod are removed, what is the charge on the leaves of the electroscope?

W) Positive
X) Negative
Y) Zero
Z) Indeterminate

ANSWER: W) POSITIVE

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TOSS-UP

22) Math – *Short Answer* Given that the areas of the faces of a rectangular prism are 6, 8, and 12, what is the volume of the rectangular prism?

ANSWER: 24

BONUS

22) Math – *Short Answer* A plane cuts a cube with side length 6 and splits it into two parts. Given that one of the parts is a triangular pyramid, find the maximum possible value of the volume of the triangular pyramid.

ANSWER: 36
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TOSS-UP

23) Earth and Space – *Short Answer* By name or number, order the following four astronomical bodies in increasing order of energy per photon emitted: 1) crab pulsar, 2) quasar 3C 273, 3) Betelgeuse, 4) Rigel.

ANSWER: 2, 3, 4, 1

BONUS

23) Earth and Space – *Multiple Choice* Due to the high penetration of x-rays, the Chandra X-Ray Observatory makes use of which of the following types of mirrors?

W) Spherical
X) Parabolic
Y) Hyperbolic
Z) Planar

ANSWER: X) PARABOLIC