TJSBT 2025

Double Elimination 7

Tossup

1. Biology – *Multiple Choice* Tardigrade typically undergo anhydrobiosis under drought conditions. During this state of anhydrobiosis, which of the following sugars do they accumulate the most of?

W) Sucrose
X) Ribose
Y) Trehalose
Z) Xylose

Answer: Y) Trehalose

Bonus

1. Biology – *Short Answer* By name or number, identify all of the following 3 plant tissues that are the product of both anticlinal and periclinal division:

1) Guard cells
2) Vascular cambium
3) Apical meristem

Answer: All

Tossup

2. Chemistry – *Multiple Choice* Which of the following is equal to the partial derivative of temperature with respect to pressure at constant entropy?

W) The partial derivative of volume with respect to entropy at constant pressure
X) The partial derivative of pressure with respect to temperature at constant volume
Y) The partial derivative of volume with respect to temperature at constant pressure
Z) The partial derivative of entropy with respect to volume at constant temperature

Answer: W) The partial derivative of volume with respect to entropy at constant pressure

Bonus

2. Chemistry – *Short Answer* What quantity represents the product of the physical path length light travels through a medium and the refractive index of that medium?

Answer: Optical path length

Tossup

3. Earth and Space – *Short Answer* By name or number, rank the following 3 features of an oceanic-continental convergent boundary in order of increasing seismicity during a deep-focus earthquake:

1) Accretionary prism
2) Forearc basin
3) Wadati-Benioff zone

Answer: 1, 2, 3

Bonus

3. Earth and Space – *Multiple Choice* Rank the following planets by increasing size of core relative to planet:

1) Mercury
2) Venus
3) Mars

ANSWER: 3, 2, 1

Tossup

4. Math – *Multiple Choice* Given that N is the least integer where N! (read: N factorial) has 500 trailing zeroes, what is N?

W) 2000
X) 2005
Y) 2010
Z) 2015

Answer: X) 2005

Bonus

4. Math – *Multiple Choice* The number of prime numbers less than one million is closest to which of the following answer choices?

W) 20,000
X) 50,000
Y) 80,000
Z) 100,000

Answer: Y) 80,000

Tossup

5. Physics – *Short Answer* What is the name of the heavy, electrically neutral meson consisting of a charm quark and its antiquark, whose simultaneous discovery at SLAC and Brookhaven in 1974 confirmed the existence of the charm quark?

Answer: J/psi meson

Bonus

5. Physics – *Short Answer* Daniel attaches a mass to a spring of spring constant k and it oscillates with period T. Caleb sets up a similar configuration, but he connects the mass to two consecutive springs of spring constant k and 3k. In terms of T and in simplest radical form, what is Caleb's period of oscillation?

Answer: $\frac{2\sqrt{3}}{3}T$

Tossup

6. Energy – *Multiple Choice* Students at Thomas Jefferson's Neuroscience Lab are using multivariate regression analysis to find trends in their results. If a student wants to determine the possible influential points and outliers, which of the following metrics would they least likely use?

W) Variance inflation factor
X) Cook's distance
Y) Studentized residuals
Z) Leverage

Answer: W) Variance inflation factor

Bonus

6. Energy – *Multiple Choice* Two possible optimizations to the Disjoint Set Union data structure are path compression and union by size. Using both of these operations results in an amortized time complexity of $O(\alpha(N))$ per operation. Which of the following statements correctly describes the improvement in the amortized time complexity per operation when using only one of the optimizations?

W) $O(log\ N)$ with only path compression, $O(log\ N)$ with only union by size
X) $O(\alpha(N))$ with only path compression, $O(log\ N)$ with only union by size
Y) $O(log\ N)$ with only path compression, $O(\alpha(N))$ with only union by size
Z) $O(\alpha(N))$ with only path compression, $O(\alpha(N))$ with only union by size

Answer: W) $O(log\ N)$ with only path compression, $O(log\ N)$ with only union by size

Tossup

7. Biology – *Multiple Choice* Which of the following is FALSE regarding carbohydrate ingestion in the small intestine?

W) Most starch digestion occurs after chyme leaves the stomach
X) Secondary active transport with sodium drives glucose and galactose uptake into enterocytes
Y) Fructose is cotransported with sodium into epithelial cells
Z) Final enzymatic digestion occurs at the brush border membrane

Answer: Y) Fructose is cotransported with sodium into epithelial cells

Bonus

7. Biology – *Short Answer* Sophia is studying paedomorphosis, or the retention of juvenile traits into an organism's adulthood. By name or number, identify all of the following 3 types of heterochrony that fall under paedomorphosis:

1) Hypermorphosis, when development continues for a longer time
2) Neoteny, when the rate of development slows
3) Predisplacement, when development begins earlier

Answer: 2 only

Tossup

8. Chemistry – *Multiple Choice* Which of the following is closest to the entropy change of vaporization, in Joules per kelvin mol, of benzene?

W) 65
X) 75
Y) 85
Z) 95

Answer: Y) 85

Bonus

8. Chemistry – *Multiple Choice* Reactions such as the azide-alkyne cycloaddition are valued for their regioselectivity, high thermodynamic driving force, and tolerance of diverse functional groups. What term is used to describe this modular class of reactions designed for rapid and reliable molecular assembly?

W) Metathesis reactions
X) SNAr substitutions
Y) Pericyclic reactions
Z) Click chemistry

ANSWER: Z) Click chemistry

Tossup

9. Earth and Space – *Multiple Choice* Sophia is making a meteorology simulation and wants to test out her pressure zones. Which of the following actions could Sophia do that would intensify her surface high pressure zone?

W) Move underneath an upper-level trough
X) Move underneath an upper-level ridge
Y) Move east of an upper-level trough
Z) Move west of an upper-level trough

Answer: Z) Move west of an upper-level trough

Bonus

9. Earth and Space – *Short Answer* By name or number, arrange the following 3 landforms typical of Basin and Range topography in the order they are most likely to develop, from earliest to latest:

1) Inselberg
2) Bajada (read as: *buh-HAH-duh*)
3) Alluvial fan

Answer: 3, 2, 1

Tossup

10. Math – *Multiple Choice* What is the sum of the eigenvalues of the 3 by 3 matrix with first row -3 4 6, second row 0, 1, -3, and third row 7, -2, 4?

W) -4
X) -2
Y) 0
Z) 2

Answer: Z) 2

Bonus

10. Math – *Short Answer* By name or number, identify all of the following 3 sets that constitute a vector space:

1) The set of points satisfying $x^2 + y^2 = 0$
2) The set of polynomials with degree less than or equal to 4
3) The set of invertible 3 by 3 matrices

Answer: 1, 2

Tossup

11. Physics – *Short Answer* What name is of the shape that allows for the fastest rate of descent for an object sliding down it?

Answer: Brachistochrone curve

Bonus

11. Physics – *Short Answer* Consider an AC circuit that has resistance 6 Ohms and a reactance across an inductor of 4 ohms. If the reactance across the capacitor is 11 Ohms, to the nearest Ohm, what is the impedance of the circuit?

Answer: 9

Halftime

Tossup

12. Energy – *Multiple Choice* Students at Thomas Jefferson's Quantum Lab are using Fast Fourier Transform in their research. If a student records the voltage signal from a photodiode detecting laser interference over time, applying Fast Fourier Transform to this data would allow the student to determine which of the following properties?

W) The dominant frequencies in the voltage signal
X) The total energy of the laser beam
Y) The coherent length of the laser
Z) The time delay between pulses

Answer: W) The dominant frequencies in the voltage signal

Bonus

12. Energy – *Multiple Choice* Students at Thomas Jefferson's Oceanography lab are studying how different gases contribute to the formation of photochemical smog. Which of the following gases is most commonly associated with the formation of ground-level ozone?

W) Nitrogen dioxide
X) Methane
Y) Carbon dioxide
Z) Sulfur dioxide

Answer: W) Nitrogen dioxide

Tossup

13. Biology – *Short Answer* What form of asexual plant reproduction, exemplified by dandelions producing clonal seeds through modified embryogenesis, involves the formation of seeds without fertilization?

Answer: Apomixis

Bonus

13. Biology – *Short Answer* Rohan is using an electron microscope to observe the inside of a cell nucleus. By name or number, identify all of the following 3 structures that are present in the nucleus:

1) Nucleolar organizing region
2) Cristae
3) Cajal body

Answer: 1, 3

Tossup

14. Chemistry – *Multiple Choice* Which of the following correctly describes the smectic phase of a liquid crystal?

W) Molecules are randomly oriented and exhibit no positional order
X) Molecules are aligned in parallel and not arranged in layers
Y) Molecules are aligned in parallel and arranged in distinct layers
Z) Molecules are disordered and form chiral helices in layered domains

Answer: Y) Molecules are aligned in parallel and arranged in distinct layers

Bonus

14. Chemistry – *Short Answer* What term refers to a functional group that, when attached to a chromophore, modifies the chromophore's ability to absorb light by shifting the absorption wavelength?

Answer: Auxochrome

Tossup

15. Earth and Space – *Short Answer* What is the name of the recently discovered gaseous compound in Venus's atmosphere that has sparked speculation about the possibility of life on the planet?

Answer: Phosphine

Bonus

15. Earth and Space – *Multiple Choice* Aarushi is doing astronomy research when she notices some of her data on cosmic microwave background radiation has fluctuations present. Which of the following answer choices best explains the fluctuations in the cosmic microwave background?

W) Sound waves propagating from photon-baryon plasma
X) Dissipation of anisotropies in dense regions
Y) Gravitational redshifting of photons during horizon crossing
Z) Decoupling of neutral hydrogens

Answer: W) Sound waves propagating from photon-baryon plasma

Tossup

16. Math – *Short Answer* What algorithm in linear algebra is used to orthonormalize the basis of a vector space?

Answer: Gram-Schmidt Process

Bonus

16. Math – *Short Answer* What is the maximum possible number of points of intersection between 3 convex triangles and 4 convex quadrilaterals?

Answer: 138

Tossup

17. Physics – *Short Answer* By name or number, identify all of the following 3 actions that would increase the self-inductance through a solenoid:

1) Increasing the number of turns in the coil
2) Increasing the space between individuals turns in the coil
3) Increasing the current through the wire

Answer: 1 only

Bonus

17. Physics – *Short Answer* A spaceship is travelling with a speed of $\frac{4}{5}c$ relative to Earth and it launches a probe with a speed of $\frac{1}{2}c$, in the same direction as the spaceship is travelling. In terms of c, what is the velocity of the probe relative to Earth?

Answer: $\frac{13}{14}c$

Tossup

18. Energy – *Short Answer* Avnith has discovered a proof that with perfect play, the first player always wins a game of chess. However, he is unable to describe a winning strategy for the first player from the starting position. What term describes the degree to which Avnith has solved chess?

Answer: Ultra-weakly solved (do not accept: weakly solved)

Bonus

18. Energy – *Multiple Choice* Students at Thomas Jefferson's Oceanography are studying manmade structures used to prevent erosion. Which of the following structures would be best suited for preventing longshore drift near harbor outlets?

W) Jetties
X) Seawalls
Y) Groins
Z) Breakwaters

Answer: W) Jetties

Tossup

19. Biology – *Short Answer* By name or number, identify all of the following 3 actions that would increase the glomerular filtration rate in a human kidney:

1) Dilation of afferent arteriole
2) Increasing plasma albumin concentration
3) Administration of epinephrine

Answer: 1 only

Bonus

19. Biology – *Multiple Choice* After missing a tossup on phylogenetic trees, Sophia is now restudying autapomorphies and synapomorphies. Which of the following is a symplesiomorphy?

W) The presence of chlorophyll a in green algae and land plants
X) The presence of wings in bats and birds
Y) The presence of a four-chambered heart in mammals but not in reptiles
Z) The evolution of feathers in birds shared with their closest dinosaur relatives

Answer: W) The presence of chlorophyll a in green algae and land plants

Tossup

20. Chemistry – *Multiple Choice* The potential energy between two neutral and non-bonded atoms can be written as a function with two terms: one for attractive van der Waals forces and another for short range electron cloud repulsion. Which of the following represents how these terms scale with distance r?

W) Attractive: r^{-12}, Repulsive: r^{-6}
X) Attractive: r^{-6}, Repulsive: r^{-12}
Y) Attractive: r^{-6}, Repulsive: r^{-3}
Z) Attractive: r^{-3}, Repulsive: r^{-6}

Answer: X) Attractive: r^{-6}, Repulsive: r^{-12}

Bonus

20. Chemistry – *Short Answer* Aaryan is studying a dilute aqueous solution containing an electrolyte. He notices that as the ionic strength of the solution increases, the activity coefficients of the dissolved ions decrease. Which principle can he use to explain and quantitatively predict this behavior?

Answer: Debye-Huckel Law

Tossup

21. Earth and Space – *Multiple Choice* Which of the following best describes how regelation contributes to the sculpting of subglacial bedforms?

W) It facilitates plastic deformation of the bedrock
X) It involves pressure melting of ice on the upstream side and refreezing downstream
Y) It creates tension cracks in the glacier that fill with debris
Z) It maintains stable temperature conditions in cold-based glaciers

Answer: X) It involves pressure melting of ice on the upstream side and refreezing downstream

Bonus

21. Earth and Space – *Multiple Choice* In another life, Sophia is a rock, more specifically a large intrusion of granite. Which of the following explains why Sophia does not contain any traces of pigeonite?

W) Pigeonite requires high pressures not found in continental crust
X) Pigeonite forms at higher temperatures than those at which granite crystallizes
Y) Pigeonite is unstable in the presence of quartz-rich melts
Z) Pigeonite commonly alters to amphibole in plutonic environments

Answer: X) Pigeonite forms at higher temperatures than those at which granite crystallizes

Tossup

22. Math – *Short Answer* A fraction is called *simple* if it is in the form 1/n, where n is a positive integer. Identify all of the following 3 statements about *simple* fractions that are true:

1) Every positive integer can be represented as a sum of distinct *simple* fractions
2) Every positive integer can be expressed as the sum of the squares of distinct *simple* fractions
3) There are infinitely many representations of 1 as the sum of *simple* fractions

Answer: 1, 3

Bonus

22. Math – *Short Answer* What is the least constant C such that $\sum_{k=1}^{\infty} \frac{2k}{k} C^k$ (read as: the sum from k equals 1 to infinity of 2k choose k times C to the power of k) diverges?

Answer: $\frac{1}{4}$

Tossup

23. Physics – *Short Answer* Two waves of the same frequency have amplitudes of 3 micrometer and 6 micrometers, respectively. If the phase difference between them is 60 degrees, what is the amplitude, to the nearest micrometer, of the resultant wave?

Answer: 8

Bonus

23. Physics – *Multiple Choice* Alice constructs a circuit consisting of a battery, 5 ohm resistor and 2 Henry inductor. Once the switch connecting the inductor is closed, which of the following is closest to the time in seconds it takes for the voltage through the inductor to reach 40% of its maximum value?

W) 0.4
X) 0.9
Y) 1.3
Z) 2.3

Answer: W) 0.4

End of packet