TJSBT 2025

Double Elimination 1

Tossup

1. Biology – *Short Answer* In plant cell division, which microtubule structure guides vesicles to build the cell plate during cytokinesis?

Answer: Phragmoplast

Bonus

1. Biology – *Multiple Choice* The Krebs cycle and electron transport chain are connected through what dual-function enzyme complex that transfers electrons directly into the electron transport chain via $FADH_2$?

W) Malate dehydrogenase
X) Succinate dehydrogenase
Y) Alpha-ketoglutaric acid dehydrogenase
Z) Isocitrate dehydrogenase

Answer: X) Succinate dehydrogenase

Tossup

2. Chemistry – *Short Answer* What term describes the number of donor atoms in a ligand that are coordinated to a central metal ion?

Answer: Denticity

Bonus

2. Chemistry – *Multiple Choice* Aaryan is trying to use distillation and other laboratory separation methods in his research project. Which of the following statements is NOT true regarding common laboratory separation methods?

W) A separatory funnel can be used to isolate mixtures based on differences in polarity
X) Water is a good solvent for recrystallizing benzoic acid because benzoic acid is soluble in hot water but not in cold water
Y) Fractional distillation is less suitable than simple distillation for separating liquids with significantly different boiling points
Z) Size exclusion chromatography separates molecules based on their mass

Answer: Z) Size exclusion chromatography separates molecules based on their mass

Tossup

3. Earth and Space – *Short Answer* By name or number, identify all of the following 3 minerals that are oxides:

1) Hematite
2) Magnetite
3) Ice

Answer: All

Bonus

3. Earth and Space – *Multiple Choice* Which of the following best describes the difference between intermittent and ephemeral streams?

W) The flow of intermittent streams is periodically blocked by physical debris, while the flow of ephemeral streams is periodically blocked by eddies
X) The flow of intermittent streams is periodically blocked by eddies, while the flow of ephemeral streams is periodically blocked by physical debris
Y) Intermittent streams tend to flow directly following a precipitation event, while ephemeral streams tend to flow during its region's wet seasons
Z) Intermittent streams tend to flow during its region's wet seasons, while ephemeral streams tend to flow directly following a precipitation event

Answer: Z) Intermittent streams tend to flow during its region's wet seasons, while ephemeral streams tend to flow directly following a precipitation event

Tossup

4. Math – *Multiple Choice* As his new year's resolution, Alex wants to read one more page each day than he did the day before. On the first day, he reads 1 page, on the second day 2, and so on. If his goal is to finish the 1500 pages in Campbell's Biology, how many days will it take him?

W) 39
X) 47
Y) 55
Z) 63

Answer: Y) 55

Bonus

4. Math – *Short Answer* By name or number, identify all of the following 4 statements concerning Rolle's Theorem that are true:

1) It is a special case of the intermediate value theorem
2) It is a special case of the mean value theorem
3) It requires the function to be differentiable on an open interval
4) It requires the function to be differentiable on a closed interval

Answer: 2, 3

Tossup

5. Physics – *Short Answer* By name or number, identify all of the following 3 actions that would reduce the period of oscillation for a simple pendulum:

1) Decreasing the length of the string
2) Releasing the pendulum closer to its resting position
3) Putting the pendulum in an accelerating car

Answer: 1, 3

Bonus

5. Physics – *Short Answer* A Carnot (read as: car-no) engine operates between two thermal reservoirs, a hot reservoir at 600 K and a cold reservoir at 480 K. If the engine absorbs 500 J of heat from the hot reservoir per cycle, what is the entropy change of the cold reservoir after one cycle?

Answer: 5/6

Tossup

6. Energy – *Multiple Choice* Students at Thomas Jefferson's Biotechnology lab are using PCR to amplify genes in the fly microbiome. After 20 cycles of PCR, approximately how many copies of DNA will be made?

W) One thousand
X) One million
Y) One billion
Z) One trillion

Answer: X) One million

Bonus

6. Energy – *Short Answer* Gabriel has a hash table with a size of 10^9 and inserts 10^5 elements into this table. Gabriel's hash function is good, but he is surprised to see that there are still quite a few collisions in his table. What probabilistic phenomenon explains this, where in a hash table with size M, one would expect to find collisions after inserting only around sqrt(M) elements?

Answer: Birthday paradox

Tossup

7. Biology – *Short Answer* Exemplified by the distinct beak morphologies of Galapagos finches, what evolutionary process happens when closely related species coexist in overlapping habitats leading to divergent traits that decrease niche overlap?

Answer: Character displacement

Bonus

7. Biology – *Short Answer* The blood of horseshoe crabs is not red due to the presence of the respiratory pigment hemocyanin instead of hemoglobin. What is the main metal cofactor in hemocyanin?

Answer: Copper

Tossup

8. Chemistry – *Short Answer* Rishabh the ammonia enjoyer has two beakers: one with ammonia from his school's lab and the other with ammonia from his house, both at equal concentrations. After performing a reaction with hydrochloric acid to form ammonium chloride, he noticed a difference in the reaction rates and realized the school ammonia was contaminated with nitrogen-15. What effect explains this difference in reaction rates?

Answer: Kinetic isotope effect

Bonus

8. Chemistry – *Short Answer* By name or number, order the following 3 ligands in terms of increasing field strength:

1) Cl^-
2) NH_3
3) CN^-

Answer: 1, 2, 3

Tossup

9. Earth and Space – *Multiple Choice* For which of the following types of supernovae would the problem of interstellar extinction be least severe?

W) Type Ia
X) Type Ib
Y) Type Ic
Z) Type II

Answer: W) Type Ia

Bonus

9. Earth and Space – *Short Answer* If a star modeled as a sphere filled with an ideal photon gas emits according to the Stefan Boltzmann law, then its heat capacity is proportional to its temperature raised to what power?

Answer: 3

Tossup

10. Math – *Short Answer* Eshaan is given a math problem with the variables x, y, and z. If x is proportional to the square of y and is inversely related to z, and x is equal to 5 when y is equal to 13 and z equals 6, what is x when y is equal to 39 and z equals 2?

Answer: 135

Bonus

10. Math – *Short Answer* By name or number, identify all of the following 3 functions that are invertible over their entire domain:

1) $\frac{1}{x}$ (read as: 1 over x)
2) x^2
3) $sin(x)$

Answer: 1 only

Tossup

11. Physics – *Short Answer* Tristan has a wave with an initial power output of P. If the wave's amplitude is doubled and its frequency is tripled, what is the resulting power output in terms of P?

Answer: 36P

Bonus

11. Physics – *Short Answer* Avnith is a very fast runner and loves running laps around his school's track. He completes one lap every 10 seconds and maintains centripetal acceleration of 4 m/s^2. To the nearest meter, what is the radius of the track?

Answer: 10

Halftime

Tossup

12. Energy – *Multiple Choice* Students at Thomas Jefferson are studying decision trees and random forest algorithms. Which of the following characteristics is best attributed to the random forest algorithm?

W) Easy to interpret
X) Unlikely to overfit a dataset
Y) Fast to build
Z) Computationally inexpensive

Answer: X) Unlikely to overfit a dataset

Bonus

12. Energy – *Multiple Choice* Students at Thomas Jefferson's Oceanography Lab are designing surfaces that can prevent runoff in local streams. To make their surfaces most impermeable to water, students should include sediments with which of the following properties?

W) Well sorted, high angularity
X) Well sorted, low angularity
Y) Poorly sorted, high angularity
Z) Poorly sorted, low angularity

Answer: Y) Poorly sorted, high angularity

Tossup

13. Biology – *Multiple Choice* Many globular proteins are typically stabilized by hydrophobic interactions involving aromatic amino acids in their cores. Which of the following amino acids would not contribute to this stability?

W) Threonine
X) Tryptophan
Y) Tyrosine
Z) Phenylalanine

Answer: W) Threonine

Bonus

13. Biology – *Short Answer* Patrick wants to estimate the size of a turtle population. He captures 56 turtles and marks them with a red dye. Later on, he recaptures 30 turtles, 4 of which are red. What is the size of the turtle population?

Answer: 420

Tossup

14. Chemistry – *Short Answer* Sophia's favorite atomic orbital is the 5p orbital. How many radial nodes does the 5p orbital have?

Answer: 3

Bonus

14. Chemistry – *Multiple Choice* Which of the following organic compounds is the strongest acid?

W) Butanoic acid
X) Butanol
Y) 2,4-hexadienoic acid
Z) Propanone

Answer: Y) 2,4-hexadienoic acid

Tossup

15. Earth and Space – *Short Answer* By name or number, rank the following 3 planets in terms of increasing greenhouse effect:

1) Mercury
2) Venus
3) Earth

Answer: 1, 3, 2

Bonus

15. Earth and Space – *Multiple Choice* X-ray emission lines originate from which region of a binary neutron star system?

W) Surface
X) Magnetosphere
Y) Accretion disk
Z) Core

Answer: Y) Accretion disk

Tossup

16. Math – *Multiple Choice* What is the average value of the function $f(x) = x^3+\sin(x)+1$ over the interval [-3, 3]?

W) 0
X) 1/2
Y) 1
Z) 3/2

Answer: Y) 1

Bonus

Math – *Short Answer* Sophia is inscribing circles in triangles as a part of TJ's tradition of inscribing random polygons into other polygons to create their logos. What is the inradius of a triangle with side lengths 13, 14, and 15?

Answer: 4

Tossup

17. Physics – *Short Answer* What term describes the average distance a particle travels between successive collisions with other particles in a medium?

Answer: Mean free path

Bonus

17. Physics – *Short Answer* A circuit consists of a 2-ohm and 3-ohm resistor connected in parallel to a 9 volt battery. What is the amount of energy dissipated by the circuit after 12 seconds?

Answer: 810 J

Tossup

18. Energy – *Short Answer* Students at Thomas Jefferson's Organic Chemistry Lab are using NMR spectroscopy to analyze the structure of organic compounds. NMR spectroscopy relies on what effect, in which nuclear energy levels split when exposed to an external magnetic field?

Answer: Zeeman effect

Bonus

18. Energy – *Multiple Choice* Students at Thomas Jefferson's Quantum lab are studying the interactions of elementary particles. Which of the following properties are conserved in strong nuclear interactions, but are not necessarily conserved in weak nuclear interactions?

W) Angular momentum
X) Electric charge
Y) Color charge
Z) Strangeness

Answer: Z) Strangeness

Tossup

19. Biology – *Short Answer* What digestive hormone stimulates the release of bicarbonate ions from the pancreas?

Answer: Secretin

Bonus

19. Biology – *Short Answer* In the presence of glucose, transcription of genes necessary to metabolize lactose decreases. This is due to the dissociation of what protein, that binds to the lac operon and promotes RNA polymerase binding?

Answer: CAP (accept: CRP)

Tossup

20. Chemistry – *Short Answer* What is the term used to describe a mixture that has equal amounts of left and right-handed enantiomers (read as: ih-NAN-tee-uh-murz) of a chiral molecule?

Answer: Racemic

Bonus

20. Chemistry – *Short Answer* How many stereoisomers does 2,3,4-tribromopentane have?

Answer: 3

Tossup

21. Earth and Space – *Multiple Choice* Avnith is testing out different computers in various climates, and wishes to see how his computers will react to being placed in an area with dry summers and wet winters. Which of the following Koppen climate designations would be best for Avnith's experiment?

W) Af
X) Bwh
Y) Csa
Z) Dsb

ANSWER: Y) Csa

Bonus

21. Earth and Space – *Short Answer* By name or number, identify all of the following 3 formations where cross-bedding would be found:

1) Sand dune
2) Flood plain
3) Submarine fan

Answer: 1 only

Tossup

22. Math – *Short Answer* By name or number, identify all of the following 3 sets of side lengths that would form an obtuse triangle:

1) 2, 2, 3
2) 3, 5, 6
3) 3, 7, 9

Answer: All

Bonus

22. Math – *Short Answer* When a cube's side length is 2 m, its volume is increasing at a rate of 40 cubic meters per second. At this instant, and in meters per second, what is the rate of change of the cube's side length?

Answer: 10/3

Tossup

23. Physics – *Short Answer* In the Michelson–Morley experiment, no shift in the interference fringes of the reflected beams was observed when the apparatus was rotated, thus disproving the existence of what medium in which light propagates?

Answer: Luminiferous Ether

Bonus

23. Physics – *Multiple Choice* Alan places three identical positive charges at the vertices of an equilateral triangle and measures the electric potential at the center of the triangle. Ryan sets up the same configuration, but he places the charges on a triangle twice as large as Alan's. Which of the following best compares the electric potentials at the centers of their triangles?

W) Alan's potential is smaller than Ryan's
X) Alan's potential is greater than Ryan's
Y) The potentials are equal and nonzero
Z) Both potentials are zero

Answer: X) Alan's potential is greater than Ryan's

End of packet