

TJSBT 2025

Double Elimination 4

Tossup

1. Biology – *Multiple Choice* Which of the following taxonomic groups is NOT monophyletic?

W) Cycadophyta
X) Chordata
Y) Amphibia
Z) Aves

Answer: Y) Amphibia

Bonus

1. Biology – *Short Answer* Lucas is interested in the inheritance pattern of blood types and decides to figure it out by finding the parents of a child with blood type O-. By name or number, identify all of the following 3 parental combinations that could produce a child with the blood type O- (O negative):

1) Mother with blood type A+, father with blood type AB-
2) Mother with blood type B-, father with blood type A-
3) Mother with blood type O-, father with blood type AB-

Answer: 2 only

Tossup

2. Chemistry – *Short Answer* What term refers to the stereochemical arrangement of repeating units along the main chain of a polymer?

Answer: Tacticity

Bonus

2. Chemistry – *Multiple Choice* Consider the reaction of hydrobromic acid with 1-butene. Which of the following correctly matches the major product and the mechanism behind its formation? The major product is:

W) 1-bromobutane because the proton from HBr attacks the C-1 carbon, forming a more stable secondary carbocation at C-2
X) 2-bromobutane because the proton from HBr attacks the C-1 carbon, forming a more stable secondary carbocation at C-2
Y) 1-bromobutane because the proton from HBr attacks the C-2 carbon, forming a more stable primary carbocation at C-1
Z) 2-bromobutane because the proton from HBr attacks the C-2 carbon, forming a more stable primary carbocation at C-1

Answer: X) The major product is 2-bromobutane because the proton from HBr attacks the C-1 carbon, forming a more stable secondary carbocation at C-2

Tossup

3. Earth and Space – *Multiple Choice* Lucas finds himself standing in a river that is quickly increasing in velocity. If the velocity of the river is doubled, by what factor is its competence multiplied?

W) 2
X) 4
Y) 8
Z) 16

Answer: X) 4

Bonus

3. Earth and Space – *Short Answer* By name or number, arrange the following 3 thunderstorm-associated luminous events in order of increasing altitude:

1) Blue jets
2) Red sprites
3) ELVES

Answer: 1, 2, 3

Tossup

4. Math – *Short Answer* If $f(x) = x\cos(x)$, what is the value of $f'(\frac{\pi}{2})$?

Answer: $-\frac{\pi}{2}$

Bonus

4. Math – *Multiple Choice* In a connected graph, which of the following operations will always result in a spanning tree?

W) Removing a vertex and all adjacent edges
X) Adding a new vertex connected to two existing vertices
Y) Removing one edge from each cycle until no cycles remain
Z) Contracting every edge of the graph

Answer: Y) Removing one edge from each cycle until no cycles remain

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Tossup

5. Physics – *Short Answer* What is the name of the constant that quantifies the strength of the electromagnetic interaction between elementary charged particles?

Answer: Fine structure constant

Bonus

5. Physics – *Short Answer* A capacitor with capacitance 60 microfarads is connected to a simple circuit. If there is 0.01 coulombs of charge on the capacitor, then to two significant figures and in Joules, what is the amount of energy stored in the capacitor?

Answer: 0.83 J

Tossup

6. Energy – *Short Answer* Students at Thomas Jefferson's Computer Systems Lab are studying representations of numbers in computer systems. The most common of these systems is the Two's complement method. Under this method, what is the largest integer that can be represented with 8 bits?

Answer: 127

Bonus

6. Energy – *Short Answer* By name or number, identify all of the following 3 statements that are true of zero-sum games:

1) It is never optimal to cooperate
2) They are 2 player games
3) One player gaining an advantage does not necessarily means another player is at a disadvantage

Answer: 1 only

Tossup

7. Biology – *Multiple Choice* Patrick is in his garden when he notices that the leaves of his sage plants are noticeably and uniformly yellowing. Which of the following nutrient deficiencies is most likely responsible for this finding?

W) Nitrogen
X) Iron
Y) Magnesium
Z) Phosphorus

Answer: W) Nitrogen

Bonus

7. Biology – *Short Answer* In female mammals, a Barr body is formed as one of two X chromosomes undergoes inactivation to ensure dosage compensation. By name or number, order the following 3 steps from first to last in the formation of a Barr body:

1) Initiation of transcription at the X-inactivation center
2) Recruitment of Polycomb repressive complexes
3) Coating of the X chromosome by Xist RNA

Answer: 1, 3, 2

Tossup

8. Chemistry – *Short Answer* Borane, or BH_3, is extremely unstable and is rarely observed in its pure form. Instead, what compound does borane typically exist in under normal conditions?

Answer: Diborane (accept B_2H_6)

Bonus

8. Chemistry – *Multiple Choice* Which of the following methods in quantum chemistry treats the motion of electrons and nuclei to be separate based on their differences in mass?

W) Hartree-Fock method
X) Born-Oppenheimer approximation
Y) Density functional theory
Z) Slater determinant approach

Answer: X) Born-Oppenheimer approximation

Tossup

9. Earth and Space – *Multiple Choice* Which of the following best explains the difference between superior and inferior mirages?

W) Superior mirages occur when light bends downward due to warmer air below cooler air, while inferior mirages occur when light bends upward due to warmer air above cooler air
X) Superior mirages occur when light bends upward due to cooler air below warmer air, while inferior mirages occur when light bends downward due to cooler air above warmer air
Y) Superior mirages occur when light bends downward due to cooler air above warmer air, while inferior mirages occur when light bends upward due to warmer air above cooler air
Z) Superior mirages occur when light bends upward due to cooler air above warmer air, while inferior mirages occur when light bends downward due to warmer air above cooler air

Answer: Z) Superior mirages occur when light bends upward due to cooler air over warmer air, while inferior mirages occur when light bends downward due to warmer air over cooler air

Bonus

9. Earth and Space – *Multiple Choice* Which of the following would best describe the polymorph transition for the mineral Al_2SiO_5 as the temperature decreases and the pressure is held at a constant high?

W) Sillimanite to andalusite
X) Andalusite to kyanite
Y) Kyanite to andalusite
Z) Sillimanite to kyanite

Answer: Z) Sillimanite to kyanite

Tossup

10. Math – *Multiple Choice* What is the maximum number of local minima for a polynomial with degree 7?

W) 2
X) 3
Y) 4
Z) 5

Answer: X) 3

Bonus

10. Math – *Short Answer* A unit cube is inscribed in a hemisphere such that its face touches the bottom of the hemisphere and its four top corners are tangent to the top surface of the hemisphere. What is the volume of this hemisphere?

Answer: $\frac{\sqrt{6}}{2}\pi$

Tossup

11. Physics – *Multiple Choice* A proton is moving in the xy plane at 45 degree angle to the x-axis. If a constant magnetic field is pointed parallel to the xy plane in the positive x direction, which of the following describes the trajectory of the proton?

W) Circle in the plane of y = x
X) Circle in the plane of z = x
Y) Helix parallel to the x-axis
Z) Helix parallel to the z-axis

ANSWER: Y) Helix parallel to the x-axis

Bonus

11. Physics – *Short Answer* Kevin holds a 6 cm blade of grass 8 cm in front of a converging lens with focal length 10 cm. To the nearest centimeter, how tall is the blade of grass in the reflection's image?

Answer: 30

Halftime

Tossup

12. Energy – *Multiple Choice* An electron is initially accelerated and then rapidly decelerates as it interacts with a proton. In the process, the electron loses energy in the form of electromagnetic radiation. Which of the following types of radiation did the electron emit?

W) Cherenkov
X) Bremsstrahlung
Y) Synchrotron
Z) Cyclotron

Answer: X) Bremsstrahlung

Bonus

12. Energy – *Short Answer* Students at Thomas Jefferson's Astronomy Lab are attempting to calculate the redshift of a distant galaxy. If the Lyman-alpha line is measured to be 972 nm, and the rest wavelength of this line is 120 nm, then to two significant figures, what is the redshift of this galaxy?

Answer: 7.1

Tossup

13. Biology – *Multiple Choice* The Ampullae of Lorenzini in sharks are used to sense which of the following stimuli?

W) Mechanical vibrations
X) Electrical currents
Y) Chemicals
Z) Light

Answer: X) Electrical currents

Bonus

13. Biology – *Short Answer* Aarushi has been prescribed a sodium channel blocker. By name or number, identify all of the following 3 phenomena that might occur if Aarushi accidentally overdoses on this medication:

1) Her cardiac myocytes will likely experience slower cell depolarization
2) Her hair cells in the Organ of Corti will likely transmit more action potentials in response to high pitched sounds
3) Her rod cells will likely remain hyperpolarized even in the dark

Answer: 1, 3

Tossup

14. Chemistry – *Multiple Choice* The energy released by an electron falling from the n=3 to the n=1 subshell of the hydrogen atom is represented as E. In terms of E, what is the energy released by an electron falling from the n = 5 to the n = 2 subshell?

W) $\frac{21}{64}E$
X) $\frac{189}{800}$E
Y) $\frac{5}{16}E$
Z) $\frac{49}{225}$E

Answer: X) $\frac{189}{800}$E

Bonus

14. Chemistry – *Multiple Choice* What equation is used to relate the molecular weight of a polymer to the degree of polymerization and the functionality of the monomers used in its synthesis?

W) Flory-Huggins equation
X) Van’t Hoff equation
Y) Carothers equation
Z) Mark-Houwink equation

Answer: Y) Carothers equation

Tossup

15. Earth and Space – *Short Answer* Lucas and Sophia are on opposite sides of a fault line and Lucas notices that Sophia is moving right relative to his location. By name or number, identify all of the following 3 types of faults that Sophia and Lucas could be standing on:

1) Dip slip
2) Strike slip
3) Oblique slip

Answer: 2, 3

Bonus

15. Earth and Space – *Multiple Choice* Rishabh the deep-sea diver has now swum himself into a body between a river and ocean where he observes a high vertical salinity gradient. Which of the following will strengthen Rishabh's perceived salinity gradient in this coastal body?

W) Tidal mixing is strengthened
X) Tidal mixing is weakened
Y) River turbulence is strengthened
Z) River turbulence is weakened

Answer: X) Tidal mixing is weakened

Tossup

16. Math – *Short Answer* How many ways are there to place 8 rooks on an 8 by 8 chessboard such that no two rooks share the same row or column?

Answer: 40,320

Bonus

16. Math – *Short Answer* Eshaan owns many cows and pigs whose weights are normally distributed with standard deviations of 11 and 7 pounds respectively. Suppose Eshaan makes enclosures holding 4 cows and 5 pigs. What is the standard deviation, in pounds, of the total weight of the animals in a typical enclosure that Eshaan constructs?

Answer: 27

Tossup

17. Physics – *Short Answer* What hypothetical spin 2 boson is predicted to carry the gravitational force?

Answer: Graviton

Bonus

17. Physics – *Short Answer* Consider a table shaped like an equilateral triangle with mass m and side length s. In terms of its weight, mg, what is the minimum amount of force required to tilt this table upwards?

Answer: $\frac{mg\sqrt{3}}{3}$

Tossup

18. Energy – *Multiple Choice* Students at Thomas Jefferson's DNA lab are studying cells in *Arabidopsis Thaliana*. Which of the following combinations of hormones would induce the growth of undifferentiated plant cells into a mass?

W) High auxin, high cytokinin
X) High auxin, low cytokinin
Y) Low auxin, high cytokinin
Z) Low auxin, low cytokinin

ANSWER: W) High auxin, high cytokinin

Bonus

18. Energy – *Multiple Choice* Students at Thomas Jefferson's Geosystems Lab are attempting to map ultra-low velocity zones using seismic tomography. Which of the following answer choices is the most probable composition of these ultra-low velocity zones?

W) Remnants of subducted ancient oceanic crust
X) Iron-rich, partially molten rock
Y) Solid perovskite-rich mantle material compressed to high densities
Z) Gas pockets composed of trapped volatiles

Answer: X) Iron-rich, partially molten rock

Tossup

19. Biology – *Multiple Choice* A pregnancy test usually turns positive because antibodies on the test strip bind to which of the following hormones?

W) Luteinizing hormone
X) Estrogen
Y) Progesterone
Z) Human chorionic gonadotropin

Answer: Z) Human chorionic gonadotropin

Bonus

19. Biology – *Short Answer* By name or number, identify all of the following 3 cells that lack a nucleus at functional maturity:

1) Albuminous cells
2) Sieve tube elements
3) Tracheids

Answer: 2, 3

Tossup

20. Chemistry – *Multiple Choice* In the partial hydrogenation of alkynes to cis-alkenes using Lindlar's catalyst, which of the following compounds is commonly used to poison the palladium catalyst and prevent further reduction to the alkane?

W) Pyridine
X) Quinoline
Y) Aniline
Z) Triphenylphosphine

Answer: X) Quinoline

Bonus

20. Chemistry – *Short Answer* What type of covalent bond results from the face-to-face overlap of two d orbitals, typically seen in some metal-metal multiple bonds and characterized by four regions of electron density?

Answer: Delta bond

Tossup

21. Earth and Space – *Multiple Choice* Dynamical friction is an important process in galactic interactions. If a massive object passes through a galactic halo at speed v, and the force of dynamical friction on the surrounding medium is F, what is the resulting force when the speed of the object is doubled?

W) F/4
X) F/2
Y) 2F
Z) 4F

Answer: W) F/4

Bonus

21. Earth and Space – *Short Answer* As gas undergoes gravitational collapse, radiation pressure resists the contraction. What is the minimum mass required to overcome this pressure and allow collapse to continue?

Answer: Jean’s mass

Tossup

22. Math – *Multiple Choice* Which of the following terms refers to how much a vector field passes through a surface?

W) Gradient
X) Directional derivative
Y) Curl
Z) Flux

Answer: Z) Flux

Bonus

22. Math – *Short Answer* Alice can climb a set of 8 stairs with either 1 or 2 steps at a time. If the order of her steps matters, how many distinct ways are there for Alice to climb the stairs?

Answer: 34

Tossup

23. Physics – *Multiple Choice* Which of the following describes the magnitude of the acceleration of a simple pendulum when it is at its maximum displacement?

W) Less than g
X) Equal to g
Y) Greater than g
Z) 0

Answer: W) Less than g

Bonus

23. Physics – *Short Answer* A fire hose is connected to a pump that delivers water at a pressure of 500 kPa. If the hose nozzle is held 5 meters above the pump outlet, to one significant figure, what is the speed of the water as it exits the nozzle?

Answer: 30 m/s

End of packet