

TJSBT 2025

Double Elimination 5

Tossup

1. Biology – *Multiple Choice* Which of the following features is the best evidence for convergent evolution between two species?

W) Apopmorphy (read as: *APP-uh-mor-fee)*
X) Sympliesopmorphy (read as: *sim-PLEE-zee-uh-mor-fee)*
Y) Synapomorphy (read as: *sin-APP-uh-mor-fee*)
Z) Homoplasy (read as: *HOH-muh-play-zee*)

Answer: Z) Homoplasy

Bonus

1. Biology – *Short Answer* During the pacemaker potential, different ion channels in a sinoatrial node cell open in a specific sequence to initiate depolarization. By name or number, order the following 3 ion channels in which they initially open to start the pacemaker potential:

1) L-type
2) F-type
3) T-type

Answer: 2, 3, 1

Tossup

2. Chemistry – *Short Answer* What is the term used to describe the inversion of configuration that occurs when a chiral center in a molecule undergoes nucleophilic substitution, leading to the opposite stereochemistry?

Answer: Walden inversion

Bonus

2. Chemistry – *Short Answer* Patrick loves studying gases, and through his studies, he is able to determine that the mean free path of a sample of argon gas at 300 kelvin is 300 nanometers. Given this information, what would you expect the mean free path of the same sample at 2700 kelvin be, in nanometers?

Answer: 2700 nm

Tossup

3. Earth and Space – *Short Answer* By name or number, rank the following 3 layers of the Earth in order of increasing internal geothermal gradient:

1) Lithosphere
2) Outer core
3) Inner core

Answer: 3, 2, 1

Bonus

3. Earth and Space – *Short Answer* By name or number, identify all of the following 3 changes that will increase the meandering of his stream:

1) Increase in sediment load
2) Increase in stream gradient
3) Decrease of riparian vegetation

Answer: All

Tossup

4. Math – *Short Answer* When performing a change of coordinates, the differential element in the expression of a double integral over a region must be multiplied by the determinant of what matrix?

Answer: Jacobian matrix

Bonus

4. Math – *Short Answer* Let $f(x) = \frac{1}{2+x}$. What is the coefficient of the x^3 in the Taylor expansion for f about x = 0?

Answer: $-\frac{1}{16}$

Tossup

5. Physics – *Multiple Choice* A particle is modeled by potential function U(x, y) = xy. If the particle is placed at point (1, 1), and taking north to be the positive y direction, in what direction will the particle accelerate?

W) Northwest
X) Northeast
Y) Southwest
Z) Southeast

Answer: Y) Southwest

Bonus

5. Physics – *Short Answer* What vector quantity, proportional to the cross product of the electric and magnetic fields, represents the energy flux of an electromagnetic field?

Answer: Poynting vector

Tossup

6. Energy – *Multiple Choice* Students at Thomas Jefferson's Computer Systems Lab are bored so they are flipping water bottles instead. If there is a 20% chance of flipping a water bottle and making it land on its base, which of the following answer choices is closest to the standard deviation of the random variable X, where X is the number of times the water bottle is flipped until it lands on its base?

W) 3.5
X) 4.0
Y) 4.5
Z) 5.0

Answer: Y) 4.5

Bonus

6. Energy – *Short Answer* By name or number, identify all of the following 3 problems that would generally use unsupervised learning over supervised learning:

1) Clustering
2) Dimensionality reduction
3) Image classification

Answer: 1, 2

Tossup

7. Biology – *Short Answer* Patrick is testing several cellular changes to increase the rate of glycogenolysis. By name or number, identify all of the following 3 molecules whose concentrations he could increase that would subsequently increase the rate of glycogenolysis:

1) Glucagon
2) Insulin
3) Cyclic AMP

Answer: 1, 3

Bonus

7. Biology – *Short Answer* What structure forms when DNA strands cross over during homologous end joining?

Answer: Holliday junction

Tossup

8. Chemistry – *Short Answer* What is the name of the effect in which the addition of spectator ions to a solution increases the solubility of a sparingly soluble salt by increasing the ionic strength of the solution?

Answer: Inert ion effect (do not accept: common ion effect)

Bonus

8. Chemistry – *Short Answer* An isolated system contains a single substance that can exist in three phases: solid, liquid, and gas. This system is at equilibrium, and has a triple point at 213 kelvin and 3.4 bars. Given this information, how many degrees of freedom exist for this system at its triple point?

Answer: 0

Tossup

9. Earth and Space – *Short Answer* By name or number, identify all of the following 3 types of galaxies that will likely have significant star formation:

1) Starburst
2) Spiral
3) Lenticular

Answer: 1, 2

Bonus

9. Earth and Space – *Multiple Choice* After going stargazing with Aarushi, Sophia is now testing out her newfound knowledge. She sees a star in the sky with a convective envelope and radiative core, and Aarushi also points out it has an apparent magnitude of about 2. Which star could this be?

W) Sun
X) Betelgeuse
Y) Polaris
Z) Sirius

Answer: Y) Polaris

Tossup

10. Math – *Short Answer* By name or number, identify all of the following 3 functions that have an infinite discontinuity at x = 0:

1) 1/(x^2) (read as: one over the quantity x squared)
2) cot(x) (read as: cotangent x)
3) |x|/x (read as: absolute value of x divided by x*)*

Answer: 1, 2

Bonus

10. Math – *Short Answer* How many numbers between 1 and 121 are divisible by 2, 3, or 5?

Answer: 88

Tossup

11. Physics – *Multiple Choice* Which of the following answer choices represents the units for viscosity?

W) Newton seconds
X) Newton seconds per meter
Y) Pascal seconds
Z) Pascal meter seconds

Answer: Y) Pascal seconds

Bonus

11. Physics – *Multiple Choice* What mathematical model in statistical mechanics is used to describe ferromagnetism in materials by representing magnetic dipole moments of atomic spins as binary variables?

W) Potts model
X) Heisenberg lattice
Y) Ising model
Z) Hubbard framework

Answer: Y) Ising model

Halftime

Tossup

12. Energy – *Short Answer* Students in the TJ Chemistry lab are measuring the mass of copper at the cathode of an electrolytic cell under constant current. By name or number, identify all of the following 3 actions that would most likely increase the molar mass of copper found at the cathode:

1) Underestimating the total Faraday constant
2) Overestimating the current used during electrolysis
3) Recording a shorter electrolysis time than the actual duration

Answer: 3

Bonus

12. Energy – *Multiple Choice* Students at Thomas Jefferson are studying advanced performance metrics, like precision, for classification algorithms. To two significant digits, what is the precision of a classifier that has 100 true positives, 150 true negatives, 100 false positives, and 25 false negatives?

W) 0.40
X) 0.50
Y) 0.67
Z) 0.86

Answer: X) 0.5

Tossup

13. Biology – *Multiple Choice* Sophia is walking around the Smithsonian Zoo and notices many animals around her. Which of the following animals is NOT triploblastic?

W) Red-bellied turtle
X) Alaskan king crab
Y) Portuguese man o' war
Z) Whooping crane

Answer: Y) Portuguese man o' war

Bonus

13. Biology – *Short Answer* After exploring for a bit, Sophia decides to leave the jellyfish exhibit. By name or number, identify all of the following muscles that Sophia would use to walk outside:

1) Quadriceps femoris
2) Biceps brachialis
3) Soleus

Answer: 1, 3

Tossup

14. Chemistry – *Short Answer* By name or number, order the following 3 compounds in terms of increasing ionic character:

1) MgO
2) LiCl
3) KI

Answer: 2, 3, 1

Bonus

14. Chemistry – *Multiple Choice* Patrick adds s-butyl chloride and sodium ethoxide into a solution of ethanol, and heats the reaction vessel. Which of the following reactions would he most expect to occur?

W) SN1
X) SN2
Y) E1
Z) E2

Answer: Z) E2

Tossup

15. Earth and Space – *Short Answer* By name or number, identify all of the following 3 spectral characteristics that are most indicative of a T Tauri star:

1) Strong lithium absorption lines
2) Absence of H-alpha emission
3) Presence of veiling continuum

Answer: 1, 3

Bonus

15. Earth and Space – *Short Answer* What planetary body in the solar system exhibits the strongest auroras despite lacking a dense atmosphere?

Answer: Jupiter

Tossup

16. Math – *Multiple Choice* To two significant figures, what is the value of 1.03^9?

W) 1.1
X) 1.2
Y) 1.3
Z) 1.4

Answer: Y) 1.3

Bonus

16. Math – *Short Answer* Alex's wardrobe contains 2 red socks and 2 blue socks. Alex draws socks one by one at random without replacement and stops as soon as he has seen at least one sock of each color. What is the expected number of socks Alex draws?

Answer: $\frac{7}{3}$

Tossup

17. Physics – *Short Answer* Sophia is serving a tennis ball. The ball initially travels horizontal with the ground but is deflected upwards by the air. This is an example of what phenomena?

Answer: Magnus effect

Bonus

17. Physics – *Short Answer* Eshaan is designing a rollercoaster that consists of a circular loop-de-loop. If the loop-de-loop has a radius of 20 m, then to the nearest meter, what is the minimum height the rollercoaster must start at to make it through the loop-de-loop?

Answer: 50 m

Tossup

18. Energy – *Short Answer* Students at Thomas Jefferson's Astronomy lab are attempting to indirectly observe Kerr blackholes by analyzing the perturbations in the evolution of a nearby binary star system. What effect describes how the rotation of a massive object drags the surrounding spacetime?

Answer: Lense-Thirring effect (accept: Frame-dragging)

Bonus

18. Energy – *Multiple Choice* Students at Thomas Jefferson's Chemistry and Nanotechnology lab are studying lithium-ion batteries. Which of the following acts as a cathode for lithium-ion batteries?

W) Graphite
X) Lithium cobalt oxide
Y) Lithium aluminum hydride
Z) Lithium manganese silicate

Answer: X) Lithium cobalt oxide

Tossup

19. Biology – *Multiple Choice* Vesicle fusion with target membranes relies on precise interactions between membrane-associated SNARE proteins. Which of the following molecules is classified as a SNARE protein?

W) Synaptobrevin
X) Synaptotagmin
Y) Synaptophysin
Z) Synapsin

Answer: W) Synaptobrevin

Bonus

19. Biology – *Multiple Choice* Which of the following virus families proliferates through double-stranded dsRNA instead of single-stranded ssRNA?

W) Orthomyxovirus
X) Paramyxovirus
Y) Reovirus
Z) Retrovirus

Answer: Y) Reovirus

Tossup

20. Chemistry – *Multiple Choice* Lucas has a solution of potassium chloride in water, and he has a passion for separating alkali metals and halogens. Which of the following is the best reagent for Lucas to separate his potassium and chloride ions?

W) 12 crown 4
X) 15 crown 5
Y) 18 crown 6
Z) 21 crown 7

Answer: Y) 18 crown 6

Bonus

20. Chemistry – *Short Answer* Sophia has a peculiar solution that changes its constant pressure heat capacity depending on its temperature. She is able to determine that the solution's constant pressure heat capacity can be expressed as $Cp\ (T) = 3T^2 + 3T - 4$, where T is in kelvins. If initially her solution is at 2 kelvin and she heats it up to 6 kelvin, then in joules, what is the enthalpy change during the heating?

Answer: 240 J

Tossup

21. Earth and Space – *Multiple Choice* Alan is relaxing on a beach when the high tide comes in and soaks his towel. Which of the following coastal regions is Alan most likely in?

W) Nearshore
X) Backshore
Y) Foreshore
Z) Upshore

Answer: Y) Foreshore

Bonus

21. Earth and Space – *Short Answer* By name or number, arrange the following 4 discontinuities of the Earth's layers in order of increasing depth:

1) Repetti
2) Gutenberg
3) Moho
4) Lehman

Answer: 3, 1, 2, 4

Tossup

22. Math – *Multiple Choice* What conic section is given parametrically by the equation $r = \frac{6}{3+2\sin\theta}$ (read as: 6 over the quantity 3 + 2 sin theta)?

W) Circle
X) Ellipse
Y) Parabola
Z) Hyperbola

Answer: X) Ellipse

Bonus

22. Math – *Short Answer* If the roots of the quadratic $x^2 - 9x + 3$ are r and s, what is $\frac{1}{r^2} + \frac{1}{s^2}$?

Answer: 25/3

Tossup

23. Physics – *Multiple Choice* In an LC circuit, by what factor does the resonant angular frequency of the circuit change if both the capacitance and inductance are doubled?

W) ¼
X) ½
Y) 2
Z) 4

Answer: X) ½

Bonus

23. Physics – *Short Answer* Jason observes that when a conductor is placed transverse to an electric current and a magnetic field oriented perpendicularly to the electric current, a potential difference forms across the conductor. When this system is cooled to low temperatures and subjected to a strong magnetic field, Jason observes that the potential difference is quantized. What phenomenon is Jason observing?

Answer: Quantum hall effect

End of packet