

# TJSBT 2025

## Double Elimination 2

## Tossup

1. Biology – *Multiple Choice* Sophia is analyzing the various proteins within a sarcomere and wants to understand sarcomere elasticity. Which of the following proteins contributes to passive elasticity in the sarcomere?

W) Myosin
X) Tropomyosin
Y) Titin
Z) Dystrophin

Answer: Y) Titin

## Bonus

1. Biology – *Short Answer* In a haplodiploid system, what is the coefficient of relatedness between two sister drones who have the same father?

Answer: 3/4

## Tossup

2. Chemistry – *Short Answer* By name or number, identify all of the following 3 intermolecular forces present in urea, which has the chemical formula $CO(NH_2)_2$:

1) London dispersion forces
2) Dipole dipole interactions
3) Hydrogen bonding

Answer: All

## Bonus

2. Chemistry – *Short Answer* By name or number, rank the following three 1 molal solutions by increasing boiling point elevation in water:

1) $MgCl_2$
2) $BaSO_4$
3) $Na_3PO_4$

Answer: 2, 1, 3

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## Tossup

3. Earth and Space – *Short Answer* Originally proposed to maintain a static universe, what is the name given to the parameter in Einstein's equations that describes energy inherent to spacetime?

Answer: Cosmological constant

## Bonus

3. Earth and Space – *Multiple Choice* Avnith is on Mercury after skipping his English class and decides to have some fun by sliding down a lobate scarp. Which of the following best explains the formation of lobate scarps on the surface of Mercury?

W) Tidal forces
X) Early volcanism
Y) Erosion from running water
Z) Contractive cooling

Answer: Z) Contractive cooling

## Tossup

4. Math – *Short Answer* If chord AB is 8 units from the center of circle O with a radius of 17, what is the length of chord AB?

Answer: 30

## Bonus

4. Math – *Short Answer* If a 3 dimensional solid is constructed with 3 triangular faces, 4 quadrilateral faces, 5 pentagonal faces, and 6 hexagonal faces, and assuming this construction is possible, how many vertices does this solid have?

Answer: 27

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## Tossup

5. Physics – *Multiple Choice* In a double-slit interference experiment, the intensity at the central bright fringe is I. What is the intensity at the position of the first bright fringe next to the central maximum, in terms of I?

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

Answer: Y) I/2

## Bonus

5. Physics – *Short Answer* By name or number, rank the following 3 speeds from slowest to fastest for a gas obeying the Maxwell-Boltzmann distribution:

1) Most probable speed
2) Average speed
3) Root mean square speed

Answer: 1, 2, 3

## Tossup

6. Energy – *Short Answer* What is the name of the family of computational problems which can be modelled as filling up a container of limited size with items?

Answer: Knapsack

## Bonus

6. Energy – *Multiple Choice* Students in Thomas Jefferson's Astronomy lab are using remote sensing technologies to study chemical features of Europa. Which of the following gasses makes up most of Europa's atmosphere?

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

Answer: W) Oxygen

## Tossup

7. Biology – *Multiple Choice* Lucas is an endoplasmic reticulum in prison cleaning his cell. He notices that many proteins in his cell are misfolded, and tags them so that they can be degraded by nearby proteosomes. Which of the following processes did Lucas just perform?

W) Acetylation
X) Methylation
Y) SUMOylation (read as: *SOO-moh-lay-shun*)
Z) Ubiquitination

Answer: Z) Ubiquitination

## Bonus

7. Biology – *Short Answer* What principle in phylogenetics favors tree building that requires the fewest evolutionary changes between different species?

Answer: Principle of maximum parsimony (accept: Occam's razor)

## Tossup

8. Chemistry – *Multiple Choice* Which of the following conditions would you expect a real gas to best model an ideal gas?

W) Low temperature, low pressure
X) Low temperature, high pressure
Y) High temperature, low pressure
Z) High temperature, high pressure

Answer: Y) High temperature, low pressure

## Bonus

8. Chemistry – *Short Answer* What is the compound commonly used as a reference standard in proton nuclear magnetic resonance spectroscopy due to its inertness and high solubility in a wide range of solvents?

Answer: Tetramethylsilane (accept: TMS)

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## Tossup

9. Earth and Space – *Multiple Choice* Rohan needs aluminum and is turning to geology to solve his problems. Which of the following ores should Rohan mine to extract his aluminum?

W) Sphalerite
X) Bauxite
Y) Magnetite
Z) Chalcopyrite

Answer: X) Bauxite

## Bonus

9. Earth and Space – *Short Answer* In his quest for bauxite, Rohan has dug himself down to a mid-ocean ridge lined with hydrothermal vents, where he notices that some of the vents are lighter in colour. By name or number, identify all of the following 3 characteristics that correctly differentiate these two types of vents:

1) Darker vents emit fluids hotter than 300°C, while lighter vents emit fluids cooler than 300°C
2) Darker vents are closer to the ridge's central axis, while lighter vents are farther away
3) Darker vents have bauxite nodules present, while lighter vents have phosphate nodules present

Answer: 1, 2

## Tossup

10. Math – *Multiple Choice* 19 students in a chemistry class have just finished taking an exam. If the lowest score is dropped, the average is 80%. If instead, the highest score is dropped, the average is 76%. What is the range of the original 19 scores?

W) 72
X) 74
Y) 76
Z) 78

Answer: W) 72

## Bonus

10. Math – *Short Answer* What is the volume when the region bounded by $x = 0$, $y = 0$, $y = x^5$, and $x = 2$ is rotated about the x-axis?

Answer: $\frac{2048}{11}\pi$

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## Tossup

11. Physics – *Short Answer* What thermodynamic principle gives the average energy for a gas per degree of freedom?

Answer: Equipartition theorem

## Bonus

11. Physics – *Multiple Choice* An isotope of Radon-222 is at rest when it undergoes alpha decay. If it emits an α-particle with speed $v$, in terms, of $v$, what is the recoil speed of its daughter nucleus?

W) $\frac{2}{109}v$
X) $\frac{2}{111}v$
Y) $\frac{1}{111}v$
Z) $\frac{1}{109}v$

Answer: W) $\frac{2}{109}v$

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**Halftime**

**Tossup**

12. Energy – *Multiple Choice* What quantum search algorithm with time complexity of O(√N), operates on the basis of amplitude amplification and an oracle function?

W) Shor's algorithm
X) Grover's algorithm
Y) Deutsch–Jozsa algorithm (read as: *Doytsh Yoh-zha)*
Z) Simon's algorithm

Answer: X) Grover's algorithm

**Bonus**

12. Energy – *Multiple Choice* Students at Thomas Jefferson's Geosystems Lab are using statistical modeling to study floods. Which of the following is closest to the probability that a 5-year flood does not occur during a 5-year period?

W) 10%
X) 30%
Y) 50%
Z) 70%

Answer: X) 30%

## Tossup

13. Biology – *Multiple Choice* Bone marrow cells are useful for transfusion, as they can differentiate into various types of blood cells. Which of the following stem cells best categorizes bone marrow cells?

W) Totipotent
X) Pluripotent
Y) Multipotent
Z) Unipotent

Answer: Y) Multipotent

## Bonus

13. Biology – *Short Answer* By name or number, identify all of the following 3 tissues that compose the periderm:

1) Phelloderm
2) Secondary xylem
3) Cork cambium

Answer: 1, 3

## Tossup

14. Chemistry – *Short Answer* What type of reaction forms a cyclic product by combining a conjugated diene with a dienophile?

Answer: Diels-Alder reaction

## Bonus

14. Chemistry – *Multiple Choice* Patrick is performing a titration experiment. He titrates a standard solution of sodium hydroxide against an unknown concentration of acetic acid. Which of the following pH indicators would be most appropriate for this titration?

W) Methyl orange
X) Bromothymol blue
Y) Phenolphthalein
Z) Methyl red

Answer: Y) Phenolphthalein

## Tossup

15. Earth and Space – *Multiple Choice* Which of the following cloud types is formed at the highest altitude?

W) Cumulus
X) Cumulonimbus
Y) Nacreous (read as: *NAY-kree-uhs)*
Z) Noctilucent (read as: nok-TIH-loo-sent)

Answer: Z) Noctilucent

## Bonus

15. Earth and Space – *Short Answer* By name or number, identify all of the following 3 characteristics of a sediment that would increase the farther away it is from its deposition source:

1) Grain size
2) Angularity
3) Porosity

Answer: 3 only

## Tossup

16. Math – *Multiple Choice* If $f(x) = \sin^2(x)*\cos^2(x)$, what is f(x) when $x = \pi/8$?

W) 1/2
X) 1/4
Y) 1/8
Z) 1/16

Answer: Y) 1/8

## Bonus

16. Math – *Short Answer* To estimate $\int_0^{12} x^2 dx$ (read as: *the integral of x squared dx from 0 to 12*), Rishabh wants to use various Riemann sum approximations. By name or number, arrange the following 4 Riemann sums in increasing value given the following integral:

1) Left-hand Riemann sum with 2 subintervals
2) Left-hand Riemann sum with 4 subintervals
3) Right-hand Riemann sum with 2 subintervals
4) Right-hand Riemann sum with 4 subintervals

Answer: 1, 2, 4, 3

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## Tossup

17. Physics – *Multiple Choice* In a semiconductor, what term describes the energy difference between the valence band and conduction band?

W) Fermi gap
X) Valence-conduction difference
Y) Energy band separation
Z) Band gap

Answer: Z) Band gap

## Bonus

17. Physics – *Short Answer* A 30 cm thick wall has a thermal conductance of 0.05 watts per meter kelvin and area of 60 square meters. If the temperature difference between the outside and inside is 20 C, then in watts, what is the rate of heat transfer across the wall?

Answer: 200

## Tossup

18. Energy – *Multiple Choice* Students at Thomas Jefferson's Oceanography Lab are studying properties of different biominerals. Which of the following biominerals is the hardest?

W) Calcite
X) Talc
Y) Biotite
Z) Magnetite

Answer: Z) Magnetite

## Bonus

18. Energy – *Short Answer* Students at Thomas Jefferson are studying the K-means and K-mode algorithms. By name or number, identify all of the following 3 statements that are true about the K-means and K-mode algorithms:

1) The K-means algorithm will always converge
2) The K-means algorithm will always converge to the best classification scheme
3) The K-mode algorithm works effectively on qualitative data

Answer: 1, 3

## Tossup

19. Biology – *Short Answer* By name or number, identify all of the following 3 receptors that play a role in regulating blood pressure:

1) Baroreceptors
2) Chemoreceptors
3) Nociceptors

Answer: 1, 2

## Bonus

19. Biology – *Multiple Choice* Which of the following species of fungi is not a basidiomycete?

W) Asparagus rust
X) Blue mycena
Y) Button mushroom
Z) Bread mold

Answer: Z) Bread mold

## Tossup

20. Chemistry – *Multiple Choice* Which of the following answer choices is NOT an assumption of the kinetic molecular theory of gases?

W) Gas molecules have negligible volume
X) Collisions between gas molecules are perfectly elastic
Y) Gases move in a predictable manner
Z) There are no intermolecular forces between individual gas molecules

Answer: Y) Gases move in a predictable manner

## Bonus

20. Chemistry – *Short Answer* Sophia is in her organic chemistry class studying Newman projections. By name or number, rank the following three Newman projection configurations of butane in terms of increasing stability:

1) Eclipsed
2) Anti
3) Gauche

Answer: 1, 3, 2

## Tossup

21. Earth and Space – *Short Answer* Given that the angular momentum of a satellite at the latus rectum of an orbit is $2.4 * 10^{15}$ kg $m^2/s$ and that the eccentricity of the satellite is 0.5, what is the angular momentum at perihelion?

Answer: $2.4 * 10^{15}$

## Bonus

21. Earth and Space – *Short Answer* By name or number, arrange the following 3 dwarf planets in order of increasing distance from the Sun:

1) Ceres
2) Eris
3) Pluto

Answer: 1, 3, 2

## Tossup

22. Math – *Multiple Choice* A set of three positive consecutive integers has a product 33 times their sum. What is the largest element in the set?

W) 11
X) 13
Y) 15
Z) 17

Answer: W) 11

## Bonus

22. Math – *Short Answer* If P(x) is a cubic polynomial such that P(1) = 4, P(2) = 9, P(3) = 16, and P(4) = 13, what is P(5) equal to?

Answer: -12

## Tossup

23. Physics – *Multiple Choice* Consider a wire carrying current that is uniformly distributed. Which of the following describes how the magnitude of the magnetic field varies with radial distance r for points inside and outside the wire, respectively?

W) $r, 1/r$
X) $r^2, 1/r$
Y) $r, 1/r^2$
Z) $r^2, 1/r^2$

Answer: W) $r, 1/r$

## Bonus

23. Physics – *Short Answer* Patrick has carved out a watermelon so it is approximately the shape of a hollow sphere. He releases the watermelon from rest at the top of a 10 meter-high incline and it begins to roll without slipping. To two significant figures and in meters per second, what is the speed of the watermelon when it reaches the ground?

Answer: 11 m/s

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**End of packet**