

TJSBT 2025

Round Robin 4

Tossup

1. Biology – *Short Answer* Eshaan is back with his model cell and now he's analyzing his extracellular matrix. By name or number, identify all of the following 3 proteins that are present within the extracellular matrix:

1) Collagen
2) Myosin
3) Fibronectin

Answer: 1, 3

Bonus

1. Biology – *Multiple Choice* Which of the following options are true regarding the vestibulocochlear cranial nerve?

W) It automatically adjusts the tension of the eardrum in response to sudden changes in pitch, preventing hearing damage without involving any other structures
X) It interprets both pressure and temperature changes in the inner ear
Y) It transmits auditory signals only from low-frequency sounds, while high-frequency sounds are carried by a separate branch of the trigeminal nerve
Z) It detects rotational movements via the semicircular canals and linear accelerations via the utricle and saccule

Answer: Z) It detects rotational movements via the semicircular canals and linear accelerations via the utricle and saccule

Tossup

2. Chemistry – *Short Answer* By name or number, order the following 3 molecules in terms of increasing bond order:

1) NO^+ (read as: N-O-plus)
2) NO
3) NO^- (read as: N-O-minus)

Answer: 3, 2, 1

Bonus

2. Chemistry – *Short Answer* If the pKa of a binary acid is 4.3, what is the pH of a solution where the acid's concentration is 10 times the conjugate base's concentration?

Answer: 3.3

Tossup

3. Earth and Space – *Multiple Choice* Which of the following elements is least abundant in the continental crust by weight percentage?

W) Oxygen
X) Silicon
Y) Aluminum
Z) Magnesium

Answer: Z) Magnesium

Bonus

3. Earth and Space – *Short Answer* By name or number, identify all of the following 3 quantities that increase as a wave approaches the shoreline:

1) Wavelength
2) Wave height
3) Wave velocity

Answer: 2 only

Tossup

4. Math – *Multiple Choice* If 5 question writers can write 30 questions in 60 minutes, how many minutes would it take 15 question writers to write 60 questions?

W) 30
X) 40
Y) 45
Z) 60

Answer: X) 40

Bonus

4. Math – *Multiple Choice* Over which of the following intervals is the function $f(x) = x^3 - x^2$ concave down and increasing?

W) $(-\infty, -2/3)$
X) $(-\infty, 0)$
Y) (0, 2/3)
Z) $(0, \infty)$

Answer: X) $(-\infty, 0)$

Tossup

5. Physics – *Multiple Choice* Unpolarized light with an initial intensity of I passes through two polarizing filters. The first filter is oriented at an angle of 0° relative to an arbitrary reference axis, and the second filter is oriented at 45° relative to the first. In terms of I, what is the final intensity of the transmitted light?

W) I/8
X) I/6
Y) I/4
Z) I/2

Answer: Y) I/4

Bonus

5. Physics – *Multiple Choice* An object of mass 4 kilograms is initially traveling with a constant velocity of 3 meters per second. A force given by $F(t) = 2t^3 + 3t^2 + 8$ is applied to the object, starting from time t=0. Which of the following answer choices is closest to the speed of the object at time t=2 seconds?

W) 8
X) 9
Y) 10
Z) 11

Answer: Z) 11

Tossup

6. Energy – *Multiple Choice* Students at Thomas Jefferson's Biotechnology lab are studying ampicillin resistance in *E. coli*. Which of the following groups represents the positive control group?

W) Ampicillin and ampicillin-resistant bacteria
X) Ampicillin and ampicillin-sensitive bacteria
Y) No ampicillin and ampicillin-resistant bacteria
Z) No ampicillin and ampicillin-sensitive bacteria

Answer: W) Ampicillin and ampicillin-resistant bacteria

Bonus

6. Energy – *Short Answer* In a nuclear reactor, what isotope of hydrogen typically makes up heavy water?

Answer: Deuterium

Tossup

7. Biology – *Short Answer* By name or number, identify all of the following 3 disorders that are Y-linked recessive:

1) Cri du chat (read as: *kree doo shah)*
2) Albinism
3) Edward's syndrome

Answer: None

Bonus

7. Biology – *Multiple Choice* Which of the following molecules acts as an inhibitor to a key regulator enzyme within glycolysis?

W) Oxaloacetate
X) Isocitrate
Y) Citrate
Z) Fumarate

Answer: Y) Citrate

Tossup

8. Chemistry – *Short Answer* What is the term given to a chemical species that acts both as a base and an acid?

Answer: Amphoteric (accept: Amphiprotic)

Bonus

8. Chemistry – *Short Answer* By name or number, order the following 3 elements in terms of decreasing electron affinity:

1) Oxygen
2) Sulfur
3) Selenium

Answer: 2, 3, 1

Tossup

9. Earth and Space – *Short Answer* By name or number, identify all of the following 3 marine organisms that form siliceous ooze:

1) Coccolithophores
2) Forams
3) Radiolarians

Answer: 3 only

Bonus

9. Earth and Space – *Multiple Choice* What percent of an air mass is located beneath the 700 millibar line?

W) 30%
X) 50%
Y) 70%
Z) 90%

Answer: W) 30%

Tossup

10. Math – *Multiple Choice* Alan again writes the positive integers 1 through 100 on a chalkboard and erases all numbers divisible by 5. If he multiplies all the remaining numbers, what is the units digit of the resulting product?

W) 2
X) 4
Y) 6
Z) 8

Answer: Y) 6

Bonus

10. Math – *Short Answer* If p is a positive integer, which of the following numbers can never be a perfect square?

1) $p^2 + p^3$
2) $p^2 + p^4$
3) $p^2 + p^3 + p^4$

Answer: 2, 3

Tossup

11. Physics – *Short Answer* By name or number, identify all of the following 3 quantities that are vectors:

1) Speed
2) Angular momentum
3) Current density

Answer: 2, 3

Bonus

11. Physics – *Short Answer* What is the name of a force that appears to act on an object when it is observed from a non-inertial reference frame?

Answer: Fictitious force (accept: Pseudoforce)

Halftime

Tossup

12. Energy – *Multiple Choice* A student is using a divide-and-conquer algorithm to efficiently sort a large dataset. Which of the following sorting algorithms is she most likely using?

W) Bubble sort
X) Miracle sort
Y) Insertion sort
Z) Quick sort

Answer: Z) Quick sort

Bonus

12. Energy – *Short Answer* Researchers at Thomas Jefferson's Organic Chemistry Lab are studying interstitial alloys. In a steel alloy, what element is typically found within the spaces between individual iron atoms?

Answer: Carbon

Tossup

13. Biology – *Short Answer* By name or number, order the following 3 sections of the small intestine from proximal to distal end:

1) Duodenum
2) Ileum
3) Jejunum

Answer: 1, 3, 2

Bonus

13. Biology – *Multiple Choice* Which of the following steps in the Krebs cycle produces NADH?

W) Citric acid to isocitric acid via aconitase
X) Alpha-ketoglutaric acid to succinyl-CoA via alpha-ketoglutarate dehydrogenase
Y) Succinyl-CoA to succinate via succinyl-CoA synthetase
Z) Succinate to fumarate via succinate dehydrogenase

Answer: X) Alpha-ketoglutaric acid to succinyl-CoA via alpha-ketoglutarate dehydrogenase

Tossup

14. Chemistry – *Short Answer* What equation in electrochemistry defines the relation between the concentrations of an ion on either side of a membrane?

Answer: Nernst equation

Bonus

14. Chemistry – *Short Answer* By name or number, identify all of the following 3 compounds which would be considered aromatic.

1) Benzene
2) Toluene
3) Cyclohexane

Answer: 1, 2

Tossup

15. Earth and Space – *Multiple Choice* Rohan is on the newly-discovered XYZ planet and wants to collect data by changing attributes of the XYZ planet and moving himself around. Which of the following changes would NOT affect the magnitude of XYZ's Coriolis force?

W) Increasing the velocity at which Rohan travels
X) Decreasing XYZ's period of rotation
Y) Increasing their latitude
Z) Increasing their longitude

Answer: Z) Increasing their longitude

Bonus

15. Earth and Space – *Short Answer* By name or number, arrange the following 3 ocean layers in the order of deepest to shallowest:

1) Bathypelagic
2) Epipelagic
3) Mesopelagic

Answer: 1, 3, 2

Tossup

16. Math – *Multiple Choice* What is the greatest number less than 100 that is the product of two prime numbers?

W) 93
X) 95
Y) 97
Z) 99

Answer: X) 95

Bonus

16. Math – *Short Answer* How many factors of 2025 are not perfect squares?

Answer: 9

Tossup

17. Physics – *Short Answer* What is the name of the process of creating a subatomic particle and its corresponding antiparticle from a neutral boson?

Answer: Pair production

Bonus

17. Physics – *Short Answer* What is the equivalent capacitance in a circuit with 3 capacitors of capacitances 2, 3, and 4 farads connected in series?

Answer: 12/13

Tossup

18. Energy – *Multiple Choice* Students at Thomas Jefferson's Quantum Lab are using neutron scattering to gain a better understanding of the structure of alloys. Neutron scattering is particularly useful for this due to which of the following properties?

W) Neutrons have a neutral electric charge
X) Neutrons can interact with all of the fundamental forces
Y) Neutrons have a half-life of approximately 10 minutes
Z) Neutrons have a spin of ½

Answer: W) Neutrons have a neutral electric charge

Bonus

18. Energy – *Short Answer* Gabriel is having trouble deciding what data structure he wants to use. If Gabriel wants a data structure with average time complexity of O(1) for insertion, deletion, and searching, and works by pairing every key to a value, what data structure should he use?

Answer: Dictionary (accept: Hash map, Hash table)

Tossup

19. Biology – *Short Answer* Lucas is preparing for the woes of junior year by staying up to finish homework and drinking copious amounts of caffeine to stay awake. This works because caffeine is considered what type of drug, characterized by its ability to speed up catecholamine transmission in the brain and increase alertness?

Answer: Stimulant

Bonus

19. Biology – *Multiple Choice* Which of the following is not true regarding angiosperms?

W) They use vessel elements to conduct water
X) They undergo cross-pollination
Y) They uses sieve cells as their primary phloem constituent
Z) In arid climates they develop bright red flowers, while in tropical climates they develop bright blue flowers

Answer: Y) They uses sieve cells as their primary phloem constituent

Tossup

20. Chemistry – *Short Answer* By name or number, identify all of the following 3 quantities which would have to be greater than zero in a spontaneous reaction:

1) Gibbs free energy change
2) Enthalpy change
3) Entropy change

Answer: None

Bonus

20. Chemistry – *Multiple Choice* Which of the following species is amphoteric?

W) Al_2O_3
X) HCl
Y) H_2O_2
Z) BaO

Answer: W) Al_2O_3

Tossup

21. Earth and Space – *Multiple Choice* Given that a spaceship's eccentricity is ⅔ and its perihelion distance is 2 AU, what is its aphelion distance?

W) 2/3 AU
X) 4 AU
Y) 10 AU
Z) 15 AU

Answer: Y) 10 AU

Bonus

21. Earth and Space – *Short Answer* Solar granules are convective cells found in what layer of the sun?

Answer: Photosphere

Tossup

22. Math – *Short Answer* By name or number, rank the following 4 numbers in increasing order:

1) Golden ratio
2) $\sqrt{2}$
3) π
4) e

Answer: 2, 1, 4, 3

Bonus

22. Math – *Short Answer* Let ABCD be a rectangle with AB = 4 and BC = 3. If M is the midpoint of AB, what is the shortest distance from M to line AC?

Answer: 6/5

Tossup

23. Physics – *Multiple Choice* The divergence of which of the following fields is always zero?

W) Electric field
X) Magnetic field
Y) Gravitational field
Z) Electromagnetic field

Answer: X) Magnetic field

Bonus

23. Physics – *Multiple Choice* Aarushi drops a penny from the top of the Eiffel Tower. Which of the following describes how the acceleration of the penny decreases with time in the presence of air resistance?

W) Linearly
X) Quadratically
Y) Exponentially
Z) Logarithmically

Answer: Y) Exponentially

End of packet