

# 2025 Texas Science Bowl Invitational

## Double Elimination 3



### Authors

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### TOSS UP

1) PHYSICS *Multiple Choice* Ben Lin is testing out a new jetpack and flies by earth at twice its escape velocity. If he immediately turns off the jetpack, what will be the shape of his resulting trajectory?

- W) Elliptical
- X) Parabolic
- Y) Hyperbolic
- Z) Spiral

ANSWER: Y) Hyperbolic

### BONUS

1) PHYSICS *Short Answer* Aldric is spinning solid iron balls on his finger like basketballs. He first tries a small ball and notices that it takes 2 Joules of energy to reach an angular velocity of 10 radians per second. In Joules, how much energy would it take to get a ball of triple the radius to spin with the same angular velocity?

ANSWER: 486

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### TOSS UP

2) EARTH AND SPACE *Multiple Choice* Which of the following stars is not part of the summer triangle asterism?

- W) Altair
- X) Deneb
- Y) Vega
- Z) Arcturus

ANSWER: Z) Arcturus

### BONUS

2) EARTH AND SPACE *Short Answer* Order the following three folds in terms of increasing stress needed for formation:

- 1) Recumbent
- 2) Overturned
- 3) Symmetrical

ANSWER: 3, 2, 1

### TOSS UP

3) CHEMISTRY *Multiple Choice* Which of the following mixtures will have a negative deviation from Raoult's [*rah-OOLTS*] law?

- W) Toluene and water
- X) Ethanol and benzene
- Y) Ethanol and water
- Z) Acetone and chloroform

ANSWER: Z) Acetone and chloroform

### BONUS

3) CHEMISTRY *Short Answer* The standard reduction potential of  $\text{Au}^+$  to Au is +1.69 V. The standard reduction potential of  $\text{Au}^{3+}$  to Au is +1.40 V. To three significant figures, what is the standard reduction potential of  $\text{Au}^{3+}$  to  $\text{Au}^+$ ?

ANSWER: +1.26 V

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### TOSS UP

4) MATH *Short Answer* Let  $ABCD$  be a quadrilateral with integral side lengths. If  $AB = 3$ ,  $BC = 4$ , and  $CD = 5$ , what is the difference between the largest and smallest possible value of  $DA$ ?

ANSWER: 10

### BONUS

4) MATH *Short Answer* What is the largest number of divisors an integer under 100 can have?

ANSWER: 12

### TOSS UP

5) BIOLOGY *Short Answer* Identify all of the following three myeloid derived cells that mature fully in the red bone marrow:

- 1) Red-blood cells
- 2) Macrophages
- 3) Eosinophils [*ee-oh-SIN-oh-fills*]

ANSWER: 3 only

### BONUS

5) BIOLOGY *Short Answer* Order the following three invertebrates by increasing age of last common ancestor with an Earthworm:

- 1) Lobster
- 2) Garden Snail
- 3) Flatworm

ANSWER: 2, 1, 3

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### TOSS UP

6) PHYSICS *Multiple Choice* The center of mass of a rigid object is travelling at a velocity 1 m/s north. Alex calculates the angular momentum and moment of inertia of the object about its center of mass and about a point one meter north of the center of mass. Which of the calculated quantities are necessarily the same for both points?

- W) Neither angular momentum nor moment of inertia
- X) Angular momentum but not moment of inertia
- Y) Moment of inertia but not angular momentum
- Z) Both angular momentum and moment of inertia

ANSWER: X) Angular momentum but not moment of inertia

### BONUS

6) PHYSICS *Short Answer* Ben Lin produces a large metal cone with height 10 meters and radius 3 meters and orients it so the tip is facing downwards. He fills the cone up with water and then drills a small hole 2 meters from the top of the cone. To one significant figure, find the exit velocity of the water from the hole.

ANSWER: 6

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### TOSS UP

7) EARTH AND SPACE *Short Answer* What winds result from an exact balance between the Coriolis force and the pressure gradient force?

ANSWER: Geostrophic winds

### BONUS

7) EARTH AND SPACE *Multiple Choice* Which of the following factors of a stream does not increase as you go from the headwaters to the mouth?

- W) Degree of meandering
- X) Gradient
- Y) Flow velocity
- Z) Channel depth

ANSWER: X) Gradient

### TOSS UP

8) CHEMISTRY *Multiple Choice* Which of the following substituents placed para to a phenol will reduce its  $pK_a$ ?

- W) Amino
- X) Nitro
- Y) Methoxy
- Z) Methyl

ANSWER: X) Nitro

### BONUS

8) CHEMISTRY *Multiple Choice* A glass tube placed horizontally connects two 1 L balloons at 298 K. The balloon on the left and right contain gaseous ammonia and hydrochloric acid respectively. Which statement best describes the reaction observed?

- W) A white powder forms on the left side of the tube
- X) A white powder forms on the right side of the tube
- Y) A white powder forms at the center of the tube
- Z) A yellow powder forms at the center of the tube

ANSWER: X) A white powder forms on the right side of the tube.

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### TOSS UP

9) MATH *Short Answer* Let  $x$  be some real number larger than 1. If  $\log_3(x) = x/9$  [READ: *log base 3 of x equals x over 9*], find  $x$ .

ANSWER: 27

### BONUS

9) MATH *Short Answer* If  $\log_3(4) \times \log_{16}(x) = 3$  [READ: *log base 3 of 4 times log base 16 of x equals 3*], what is  $x$ ?

ANSWER: 729

### TOSS UP

10) BIOLOGY *Short Answer* Order the following three organisms based on increasing time spent in the haploid phase of its sexual life cycle:

- 1) Baker's yeast
- 2) Desert kangaroo rat
- 3) Dandelion

ANSWER: 2, 3, 1

### BONUS

10) BIOLOGY *Multiple Choice* Researchers from Brown University are studying protein-nucleic acid interactions. Using a novel software called BindCompare, researchers can identify proteins that bind to similar nucleic acid sequences. Which of the following procedures would provide the most relevant data for this software?

- W) SDS-PAGE
- X) X-ray crystallography
- Y) Flow cytometry
- Z) CHIP-Seq [*Chip-Seek*]

ANSWER: Z) CHIP-Seq

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### TOSS UP

11) PHYSICS *Short Answer* An object is placed 2 meters from a concave mirror with a radius of curvature of 6 meters. Which of the following will increase the size of the image? 1) moving the object closer to the mirror, 2) increasing the radius of curvature of the mirror, 3) replacing the mirror with a convex lens with the same focal length

ANSWER: None

### BS

11) PHYSICS *Short Answer* A ball is dropped from rest into an inverted, frictionless hemisphere and begins oscillatory motion. Identify all of the following planes which could contain the locus of the center of the ball: 1) A Horizontal Plane; 2) A Vertical Plane; 3) An inclined plane which is neither horizontal nor vertical

ANSWER: 2

### TOSS UP

12) EARTH AND SPACE *Multiple Choice* Which of the following stars is not part of the summer triangle asterism?

- W) Altair
- X) Deneb
- Y) Vega
- Z) Arcturus

ANSWER: Z) Arcturus

### BONUS

12) EARTH AND SPACE *Multiple Choice* Which of the following stellar type and interior structure pairings is incorrect?

- W) A star with 0.2 solar masses: fully convective interior
- X) A star with 1 solar mass: radiative core and convective envelope
- Y) A star with 3.5 solar masses: convective core and radiative envelope
- Z) A star with 6 solar masses: fully radiative interior

ANSWER: Z) A star with 6 solar masses: fully radiative interior

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### TOSS UP

13) CHEMISTRY *Multiple Choice* Which of the following terms best describes the stereochemistry of an  $S_N2$  reaction?

- W) stereoselective [*STAIR-ee-oh-selective*]
- X) stereospecific [*STAIR-ee-oh-specific*]
- Y) diastereoselective [*die-ah-STAIR-ee-oh-selective*]
- Z) enantioselective [*eh-NANT-ee-oh-selective*]

ANSWER: X) stereospecific

### BONUS

13) CHEMISTRY *Multiple Choice* The  $pK_{a1}$  and  $pK_{a2}$  values of carbonic acid are approximately 6 and 10 respectively. Which best describes the ratio of bicarbonate to carbonate ions in a buffered solution at pH 7?

- W) 1 to 1
- X) 10 to 1
- Y) 100 to 1
- Z) 1000 to 1

ANSWER: Z) 1000 to 1

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### TOSS UP

14) MATH *Multiple Choice* Let  $f(x)$  be a continuous function with  $f(1) = 3$  [READ:  $f$  of 1 equals 3] and  $f(3) = 7$  [READ:  $f$  of 3 equals 7]. Which of the following values must  $f$  take on the open interval  $(1, 3)$ ?

- W) 1
- X) 3
- Y) 5
- Z) 7

ANSWER: Y) 5

### BONUS

14) MATH *Multiple Choice* Which of the following figures is not a platonic solid:

- W) Cube
- X) Dodecahedron [*dough-deck-a-hee-dron*]
- Y) Tetrahedron [*tet-ra-hee-dron*]
- Z) Icosidodecahedron [*eye-cos-ee-do-deck-a-hee-dron*]

ANSWER: Z) Icosidodecahedron

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### TOSS UP

15) BIOLOGY *Short Answer* Order the following 3 plants by increasing tolerance to shade:

- 1) Gray Birch
- 2) Coast Redwood
- 3) Butterfly Milkweed

ANSWER: 3, 1, 2

### BONUS

15) BIOLOGY *Multiple Choice* Which of the following diseases is not caused by a single-stranded RNA virus?

- W) Measles
- X) Common Cold
- Y) Smallpox
- Z) HIV

ANSWER: Y) Smallpox

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### TOSS UP

16) PHYSICS *Multiple Choice* Aprameya shines a beam of light onto a crystal and notices it splits into two beams with perpendicular polarizations. What property can he conclude that this material has?

- W) Optical activity
- X) Dispersion
- Y) Birefringence
- Z) Optical bistability

ANSWER: Y) Birefringence

### BONUS

16) PHYSICS *Short Answer* Which of the following are true about the angular momentum of a rigid body in three dimensions?

- 1) The total angular momentum is independent of the choice of origin
- 2) Torque is equal to the time derivative of angular momentum
- 3) Angular momentum is always parallel to the angular velocity

ANSWER: 2

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### TOSS UP

17) EARTH AND SPACE *Short Answer* Lava worlds are molten exoplanets that orbit extremely close to their host star. Identify all of the following statements regarding lava worlds that are likely true:

- 1) They are terrestrial planets
- 2) They experience strong tidal heating
- 3) Their rotational and orbital periods are equal

ANSWER: All

### BONUS

17) EARTH AND SPACE *Multiple Choice* The Hertzsprung gap is the lack of stars between the A5 and G5 spectral type, located between the top of the main-sequence and the red giants in the Hertzsprung-Russell Diagram. When a star crosses this region, what stage of fusion is the star undergoing?

- W) Started hydrogen fusion in the core
- X) Finished hydrogen fusion in the core
- Y) Started helium fusion in the core
- Z) Finished helium fusion in the core

ANSWER: X) Finished hydrogen fusion in the core

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### TOSS UP

18) CHEMISTRY *Multiple Choice* Entropy is directly proportional to what mathematical function of the number of microstates available to a system, denoted omega?

- W) Omega
- X) Omega squared
- Y) E to the power of omega
- Z) Natural log of omega

ANSWER: Z) Natural log of omega

### BONUS

18) CHEMISTRY *Short Answer* By name or number, identify which of the following three molecular geometries can exhibit cis-trans isomerism?

- 1) Tetrahedral
- 2) Square planar
- 3) Octahedral

ANSWER: 2 and 3 only

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### TOSS UP

19) MATH *Short Answer* How many triangles with integer side lengths have perimeter 6?

ANSWER: 1

### BONUS

19) MATH *Short Answer* What is the maximum possible area of a triangle with integer side lengths with perimeter 14?

ANSWER:  $2\sqrt{21}$

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## TOSS UP

20) BIOLOGY *Short Answer* Scientists studying the behaviors of migratory birds have found that young birds that do not migrate with their parents still migrate to the appropriate direction in the appropriate season. These results suggest that migration is what type of behavior?

ANSWER: Innate

## BONUS

20) BIOLOGY *Multiple Choice* Trypsin and Chymotrypsin [*kime-o-trip-sin*] are both proteases [*pro-tee-aces*] which cut polypeptides at different loci [*low-sigh*]. Trypsin cuts at lysines and arginines while chymotrypsin cuts at tyrosine, tryptophan, and phenylalanine [*feen-il-alanine*]. Which of the following best accounts for this difference?

- W) Trypsin relies on a negatively charged aspartic acid residue for catalysis; Chymotrypsin does not
- X) Chymotrypsin relies on a negatively charged aspartic acid residue for catalysis; Trypsin does not
- Y) Trypsin has a hydrophobic pocket near its active site; Chymotrypsin does not
- Z) Chymotrypsin has a hydrophobic pocket near its active site; Trypsin does not

ANSWER: Z) Chymotrypsin has a hydrophobic pocket near its active site; Trypsin does not

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### TOSS UP

21) PHYSICS *Short Answer* Aryan finds a Kaon composed of an up quark and a strange antiquark. Which of the following forces does this Kaon interact with?

- 1) Strong force
- 2) Weak force
- 3) Electromagnetic force

ANSWER: 1, 2, 3

### BONUS

21) PHYSICS *Short Answer* Krutharth is studying sound waves in an ideal gas. He measures the speed of sound in an ideal gas at 10 degrees Celsius, then heats the sample of gas to 300 degrees Celsius. To one significant figure, by what factor is the speed of sound multiplied by as a result of heating the gas?

ANSWER: 1

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### TOSS UP

22) EARTH AND SPACE *Multiple Choice* Eric examines a sedimentary rock outcrop and observes a vertical sequence from top to bottom of limestone, shale, and sandstone. Which of the following can he best conclude about the geologic history of this area?

- W) The sea levels rose
- X) The sea levels fell
- Y) The area was affected by tectonic uplift
- Z) The area was affected by saltwater intrusion

ANSWER: W) The sea levels rose

### BONUS

22) EARTH AND SPACE *Short Answer* What is the term for the energy barrier that prevents atomic nuclei from fusing unless they have enough energy to overcome their mutual repulsion?

ANSWER: Coulomb Barrier

### TOSS UP

23) CHEMISTRY *Short Answer* What is the anhydride of nitric acid?

ANSWER: Dinitrogen pentoxide [ACCEPT:  $\text{N}_2\text{O}_5$ ]

### BONUS

23) CHEMISTRY *Short Answer* Which of the following three compounds can be used as primary standards:

- 1) Sodium hydroxide
- 2) Potassium carbonate
- 3) n-Butyllithium

ANSWER: 2 only

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### TOSS UP

24) MATH *Multiple Choice* What is the largest number of points two distinct conics can intersect at?

- W) 1
- X) 2
- Y) 3
- Z) 4

ANSWER: Z) 4

### BONUS

24) MATH *Short Answer* Triangle ABC has the same circumcenter and orthocenter. If triangle ABC has perimeter 18, find its area.

ANSWER:  $9\sqrt{3}$

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### TOSS UP

25) BIOLOGY *Short Answer* The use of botulinum toxin is a common cosmetic treatment for wrinkles. Botulinum toxin relaxes muscles in the face by degrading what family of proteins, required for the release of neurotransmitters in the neuromuscular junction?

ANSWER: SNARE [ACCEPT: v-SNARE, t-SNARE]

### BONUS

25) BIOLOGY *Multiple Choice* According to the nearly neutral theory of evolution, what is the primary factor in determining the fate of slightly deleterious mutations?

- W) Genome-wide mutation rate
- X) Effective population size
- Y) Strength of selective pressures
- Z) Recombination rate within the population

ANSWER: X) Effective population size

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