

# 2025 Texas Science Bowl Invitational

## Double Elimination 7



### Authors

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### TOSS UP

1) CHEMISTRY *Short Answer* What simple quantum mechanical model predicts the transitions in infrared vibrational spectroscopy?

ANSWER: Quantum harmonic oscillator

### BONUS

1) CHEMISTRY *Multiple Choice* Which of the following statements best describes why carbon monoxide-metal complexes are more likely to be low spin, compared to metal aquo complexes?

- W) Carbon monoxide is a stronger pi-acceptor than water
- X) Water bonds to metals with an oxygen atom, while carbon monoxide bonds with a carbon atom
- Y) Carbon monoxide-metal complexes are more likely to be tetrahedral than water-metal complexes
- Z) Carbon monoxide is a stronger sigma-donor than water

ANSWER: W) Carbon monoxide is a stronger pi-acceptor than water

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### TOSS UP

2) MATH *Short Answer* What is the maximum possible rank of a 4 by 4 matrix with determinant 0?

ANSWER: 3

### BONUS

2) MATH *Short Answer* Evan draws 10 circles in the plane. What is the maximum number of regions they can enclose?

ANSWER: 91

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### TOSS UP

3) EARTH AND SPACE *Multiple Choice* Which of the following minerals is the most stable at Earth's surface?

- W) Orthoclase
- X) Anorthite
- Y) Albite
- Z) Labradorite

ANSWER: W) Orthoclase

### BONUS

3) EARTH AND SPACE *Short Answer* An earthquake occurs at the Tropic of Cancer. Identify all of the following locations that are correctly matched to the earthquake waves received there:

- 1) North pole: P waves and S waves
- 2) South pole: No earthquake waves
- 3) Tropic of Capricorn: P waves but not S waves

ANSWER: 1 only

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### TOSS UP

4) BIOLOGY *Multiple Choice* Kian discovers a mutant allele in *Drosophila*. He notes that a mutant with one wild type allele and one mutant allele forms 4 legs on average, and that a mutant with a deletion and only one mutant allele forms 5 legs on average. Which of the following is most likely correct about the wild-type gene and the mutation?

- W) The wild-type allele promotes leg formation and the mutation decreases transcription of the gene
- X) The wild-type allele inhibits leg formation and the mutation decreases transcription of the gene
- Y) The wild-type allele promotes leg formation and the mutation increases transcription of the gene
- Z) The wild-type allele inhibits leg formation and the mutation increases transcription of the gene

ANSWER: Z) The wild-type allele inhibits leg formation and the mutation increases transcription of the gene

### BONUS

4) BIOLOGY *Short Answer* Cohesin and CCCTC-binding factor (CTCF) interact to form what type of genomic region, which insulates enhancer-promoter interactions?

ANSWER: Topologically associating domains (TADs)

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### TOSS UP

5) PHYSICS *Multiple Choice* Which of the following pairs of events would not be considered time-like separated?

- W) Flipping a coin on Earth and flipping a coin on Mars one second later
- X) Shining a laser through a glass pane at a detector and detecting the laser
- Y) Dropping a ball from a building and the same ball hitting the ground
- Z) Measuring the position of a planet and measuring the position of the same planet one year later

ANSWER: W) Flipping a coin on Earth and flipping a coin on Mars one second later

### BONUS

5) PHYSICS *Short Answer* Ben Lin is studying a standing sound wave in a three-dimensional box with a side length of one meter. He notices that the wavelength in any direction is at least one meter. What is the number of distinct such waves he can generate?

ANSWER: 26

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### TOSS UP

6) BIOLOGY *Multiple Choice* Sue uses CRISPR-Cas9 to knock out Tryptophan Synthase in Zuko's pea plant. Which of the following would be a direct effect of this mutation?

- W) Premature germination of the seed
- X) Stunted growth of the main shoot
- Y) Inhibited triple response
- Z) Decreased drought tolerance

ANSWER: X) Stunted growth of the main shoot

### BONUS

6) BIOLOGY *Short Answer* The drug octreotide, used to treat Zollinger-Ellison Syndrome, has side effects including decreased metabolism, a slowed heartbeat, and weight gain. This drug is a synthetic analog of what gastrointestinal hormone?

ANSWER: Somatostatin

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### TOSS UP

7) CHEMISTRY *Multiple Choice* Which of the following compounds has a geometry most similar to the transition state of an aldol reaction?

- W) Cyclohexane
- X) Benzene
- Y) Cyclooctatetraene
- Z) Norborane

ANSWER: W) Cyclohexane

### BONUS

7) CHEMISTRY *Multiple Choice* Computational chemistry software can perform vibrational analysis of a molecule. Eigenvalues of what matrix describe the normal vibrational modes of a molecule?

- W) Gaussian
- X) Hessian
- Y) Jacobian
- Z) Identity

ANSWER: X) Hessian

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### TOSS UP

8) PHYSICS *Multiple Choice* Aldric is studying the first excited state of a particle in a one-dimensional infinite well. If he measures the location of the particle, where is it most likely to be found?

- W) At the center of the well
- X) Near the ends of the well
- Y) Halfway between the center and ends of the well
- Z) The particle is equally likely to be in all parts of the well

ANSWER: Y) Halfway between the center and ends of the well

### BONUS

8) PHYSICS *Short Answer* The time it takes for a point charge to hit a uniform conducting sheet is proportional to the distance between the point charge and the sheet raised to what power?

ANSWER: 3/2

### TOSS UP

9) EARTH AND SPACE *Short Answer* Identify all of the following three factors that would accelerate the carbonate-silicate cycle:

- 1) Higher sea levels
- 2) Warmer global temperatures
- 3) Increased volcanic activity

ANSWER: 2 and 3 only

### BONUS

9) EARTH AND SPACE *Short Answer* The tachocline is the transition region of stars between the radiative interior and the differentially rotating outer convective zone. Identify all of the following three types of stars that would have a tachocline:

- 1) White dwarf
- 2) Brown dwarf
- 3) Red dwarf

ANSWER: None

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### TOSS UP

10) MATH *Short Answer* An ellipse with foci X and Y has a major axis of length 26 and a minor axis of length 24. A point A lies on this ellipse. What is the largest possible length of XA?

ANSWER: 18

### BONUS

10) MATH *Short Answer* How many invertible 2x2 matrices have all elements equal to either 0 or 1?

ANSWER: 6

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### TOSS UP

11) CHEMISTRY *Multiple Choice* Which of the following nitrogen compounds will form imines with acetone most rapidly?

- W) Hydrazine
- X) Aniline
- Y) Methylamine
- Z) Pyridine

ANSWER: W) Hydrazine

### BONUS

11) CHEMISTRY *Short Answer* By name or number, order the following 3 compounds in terms of increasing pK<sub>a</sub>:

- 1) 2-hydroxybenzoic acid
- 2) 3-hydroxybenzoic acid
- 3) 4-hydroxybenzoic acid

ANSWER: 1, 2, 3

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### TOSS UP

12) BIOLOGY *Multiple Choice* In which of the following echinoderm clades would one expect to find an Aristotle's lantern?

- W) Asteroidea
- X) Echinoidea
- Y) Holothuroidea
- Z) Ophiuroidea

ANSWER: X) Echinoidea

### BONUS

12) BIOLOGY *Multiple Choice* Premarin is the trade name for a pharmaceutical drug extracted from the urine of a pregnant mare in its third trimester. Which of the following is least likely the active compound in this drug?

- W) Progesterone
- X) Gonadotropin
- Y) Estrogen
- Z) Prolactin

ANSWER: X) Gonadotropin

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### TOSS UP

13) PHYSICS *Multiple Choice* Aldric observes the decay of a pi plus meson into two particles. Which two particles did he observe?

- W) Muon and muon neutrino
- X) Muon and muon antineutrino
- Y) Antimuon and muon neutrino
- Z) Antimuon and muon antineutrino

ANSWER: Y) Antimuon and muon neutrino

### BONUS

13) PHYSICS *Short Answer* Aldric is juggling oranges. Given that he catches and throws balls at a constant rate, what is the ratio of the power he needs to exert to juggle four balls versus three?

ANSWER:  $\frac{64}{27}$

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### TOSS UP

14) MATH *Short Answer* Which of the following facts are true about pairs of distinct monic parabolas:

- 1) They intersect whenever their vertices have different x-coordinates
- 2) They can intersect twice
- 3) They can have the same vertex

ANSWER: 1

### BONUS

14) MATH *Short Answer* What is the largest integer that cannot be written as the sum of nonnegative multiples of 98, 99, and 100?

ANSWER: 4801

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### TOSS UP

15) EARTH AND SPACE *Short Answer* The rounded, smooth shape of a transiting exoplanet's light curve results from what phenomenon, caused by the varying opacity and temperature across a star's photosphere?

ANSWER: Limb Darkening

### BONUS

15) EARTH AND SPACE *Short Answer* Aldric observes two stars, Star A and Star B, which initially have the same luminosity but appear to have different brightness levels. Later, Star B's temperature is reduced to half and its radius is doubled. After these changes, Star A and Star B appear equally bright. What is the ratio of the parallax angle of Star A to the parallax angle of Star B?

ANSWER: 1/2

### TOSS UP

16) BIOLOGY *Multiple Choice* Which of the following vitamins is correctly matched with the symptoms of its deficiency?

- W) Thiamine, paralysis and loss of feeling in the limbs
- X) Cobalamin, swollen and bleeding gums
- Y) Folic acid, microcytic anemia
- Z) Phylloquinone, weakened bones

ANSWER: W) Thiamine, paralysis and loss of feeling in the limbs

### BONUS

16) BIOLOGY *Multiple Choice* You perform a series of tests on an unknown substance. When reacted with Benedict's reagent, the resulting solution is blue. With Barfoed's reagent, the resulting solution is blue. When reacted with Lugol's reagent, the resulting solution is orange. Which of the following molecules is most likely to be the unknown?

- W) Glucose
- X) Galactose
- Y) Sucrose
- Z) Glycogen

ANSWER: Y) Sucrose

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### TOSS UP

17) PHYSICS *Short Answer* The Debye model of a solid improves upon which older model of crystalline solids that treats solids as an ensemble of independent quantum harmonic oscillators?

ANSWER: Einstein solid (Accept: Einstein model)

### BONUS

17) PHYSICS *Short Answer* Aprameya connects a 12 Ohm resistor, 4 Farad capacitor, and 9 Henry inductor in parallel to a 6 Volt AC source. To two significant figures, what angular frequency maximizes the current amplitude through the resistor?

ANSWER: 0.17

### TOSS UP

18) CHEMISTRY *Multiple Choice* In an analogous reaction to cyclic acetal formation, a ketone can be converted to a dithioacetal. Deprotonation of this dithioacetal reverses the electrophilic carbonyl to a nucleophilic thioacyl anion. What term describes this polarity reversal?

ANSWER: Umpolung

### BONUS

18) CHEMISTRY *Short Answer* In the hydrolysis of esters, an imidazole catalyst accelerates the reaction by replacing the alkoxy group to form an intermediate. By name or number, identify what roles imidazole plays in this mechanism:

- 1) Nucleophile
- 2) Leaving group
- 3) Base

ANSWER: All

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### TOSS UP

19) EARTH AND SPACE *Short Answer* Identify all of the following three laws that would still hold true if gravity was proportional to distance to the negative third power:

- 1) Kepler's first law
- 2) Kepler's second law
- 3) Kepler's third law

ANSWER: 2 only

### BONUS

19) EARTH AND SPACE *Multiple Choice* The Schwarzschild radius of a black hole is 4 AU. In AU, which of the following is the radius of the innermost stable circular orbit and the radius of the photon sphere respectively?

- W) 3 AU, 1.5 AU
- X) 1.5 AU, 3 AU
- Y) 12 AU, 6 AU
- Z) 6 AU, 12 AU

ANSWER: Y) 12 AU, 6 AU

### TOSS UP

20) MATH *Short Answer* What is the product of the eigenvalues of the matrix with first row (2, 3) and second row (3, 2)?

ANSWER: -5

### BONUS

20) MATH *Short Answer* What is the largest integer  $n$  for which  $n$  divides  $(n-4)!+10$ ?

ANSWER: 61

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### TOSS UP

21) BIOLOGY *Multiple Choice* The glyoxylate cycle is an anabolic pathway found in some plants and fungi. It shares all of the following intermediates with the citric acid cycle except for which one?

- W) Isocitrate
- X) Alpha-ketoglutarate
- Y) Succinate
- Z) Oxaloacetate

ANSWER: X) Alpha-ketoglutarate

### BONUS

21) BIOLOGY *Short Answer* Identify all of the following that may be consequences of removing the root cap of a eudicot root:

- 1) Cytokinins will leak into the surrounding soil
- 2) The root is equally likely to grow against or with gravity
- 3) The root will more easily penetrate the soil

ANSWER: 1 and 2 only

### TOSS UP

22) MATH *Short Answer* There are 50 ants on a stick. The leftmost 30 walk right, the rightmost 20 walk left. They turn around instantly upon meeting. Eventually, all ants fall off. What is the total number of times two ants cross paths?

ANSWER: 600

### BONUS

22) MATH *Short Answer* Again, with 50 ants on a stick, 30 walking right and 20 walking left, the fifth ant from the left crosses paths with how many other ants?

ANSWER: 9

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### TOSS UP

23) EARTH AND SPACE *Multiple Choice* In the Northern Hemisphere, if you stand with the wind at your back, which direction is the low-pressure region located?

- W) In front of you
- X) Behind you
- Y) To your right
- Z) To your left

ANSWER: Z) To your left

### BONUS

23) EARTH AND SPACE *Short Answer* Identify all of the following three characteristics that describe a wintertime beach:

- 1) Steep beach face
- 2) Prominent longshore bar
- 3) Wide berm

ANSWER: 2 only

### TOSS UP

24) PHYSICS *Multiple Choice* Krutharth is a charged particle orbiting a black hole at ultra relativistic speeds, causing him to emit radiation as described by the Larmor formula. What type of radiation is being emitted?

- W) Gyromagnetic
- X) Cyclotron
- Y) Synchrotron
- Z) Bremsstrahlung

ANSWER: Y) Synchrotron

### BONUS

24) PHYSICS *Short Answer* Two speakers in a line, 1 meter apart, play a pure frequency in phase. A listener far away at a 60 degree angle hears destructive interference. In meters, what is the maximum possible wavelength of the sound?

ANSWER: 1

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### TOSS UP

25) CHEMISTRY *Multiple Choice* Which of the following halide leaving groups is most reactive in nucleophilic aromatic substitution?

- W) Fluoro
- X) Chloro
- Y) Bromo
- Z) Iodo

ANSWER: W) Fluoro

### BONUS

25) CHEMISTRY *Multiple Choice* The prochiral ketone (S)-3-methoxy-2-pentanone is reduced with sodium borohydride. Which of the following best describes the stereochemistry of the major product?

- W) 2R, 3R
- X) 2R, 3S
- Y) 2S, 3R
- Z) 2S, 3S

ANSWER: Z) 2S, 3S