

# 2025 Texas Science Bowl Invitational

Double Elimination 4



## Authors

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## TOSS UP

1) EARTH AND SPACE *Short Answer* Ben has a sandpit in his backyard. Identify all of the following three actions Ben can take to maximize the amount of sediment moved in his sandpit by the wind:

- 1) Increasing the wind speed
- 2) Replacing the sand in the sandpit with silt
- 3) Increase the surface moisture of the sediment.

ANSWER: 1 and 2 only

## BONUS

1) EARTH AND SPACE *Short Answer* Ben wants to create the steepest possible pile of sediment without it collapsing. Identify all of the following three actions he can take to maximize the angle of repose of the sediment:

- 1) Increasing the roundness of the sediment
- 2) Decreasing the grain size of the sediment
- 3) Sorting the sediment by grain size

ANSWER: None

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## TOSS UP

2) PHYSICS *Short Answer* Find the moment of inertia, in kilogram meters squared, of a thin disk of radius 2 meters and mass 10 kilograms about an axis passing through its center, parallel to the face of the disk.

ANSWER: 10

## BONUS

2) PHYSICS *Short Answer* Aprameya pours a film of oil with a density of 0.7 grams per cubic centimeter over a container of water. He then places a small cube with a side length of 1 centimeter and a density of 0.8 grams per cubic centimeter into the container. Given that the cube is completely submerged, find the minimum thickness of the oil film, in centimeters, to two significant figures.

ANSWER: 0.67

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## TOSS UP

- 3) MATH *Short Answer* How many positive integers are equal to 10 times the product of their digits?

ANSWER: 0

## BONUS

- 3) MATH *Short Answer* Two points in the coordinate plane are a Euclidean distance of 4 units apart from each other. What is the largest possible Manhattan distance between them?

ANSWER:  $4\sqrt{2}$

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## TOSS UP

- 4) CHEMISTRY *Multiple Choice* Which of the following best describes how the oxidation state of phosphorus changes when phosphorus pentachloride reacts with water?

- W) Phosphorus goes from +5 to +7.
- X) Phosphorus goes from +5 to +3.
- Y) Phosphorus goes from +5 to 0.
- Z) The oxidation state of phosphorus does not change.

ANSWER: Z) The oxidation state of phosphorus does not change.

## BONUS

- 4) CHEMISTRY *Multiple Choice* Which best describes the rate-dependence of reaction on the concentration of substrate according to the Michaelis-Menten model?

- W) Zeroth order at low concentrations, first order at high concentrations
- X) First order at low concentrations, zeroth order at high concentrations
- Y) First order at low concentrations, second order at high concentrations
- Z) Second order at low concentrations, first order at high concentrations

ANSWER: X) First order at low concentrations, zeroth order at high concentrations

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## **TOSS UP**

- 5) BIOLOGY *Short Answer* Which complement pathway can be activated by spontaneous hydrolysis of complement C3?

ANSWER: Alternative pathway

## **BONUS**

- 5) BIOLOGY *Short Answer* Embryological evidence suggests that the malleus and the incus were originally bones of the jaw in the ancestors of mammals. In the present day, these bones are responsible for amplifying sound to the eardrum. What term best describes the evolutionary shift in the function of malleus and incus?

ANSWER: Exaptation

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## **TOSS UP**

- 6) EARTH AND SPACE *Short Answer* Widmanstätten patterns are predominantly composed of what two elements?

ANSWER: Iron and Nickel

## **BONUS**

- 6) EARTH AND SPACE *Short Answer* At the beginning or end of the totality phase of a total solar eclipse, a small piece of the Sun's photosphere can peek out through a valley at the edge of the moon. What is the name for this phenomenon?

ANSWER: Bailey's Beads [ACCEPT: Diamond Ring Effect]

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## **TOSS UP**

7) PHYSICS *Multiple Choice* The lifetime of muons travelling from space is anomalously high as measured from earth. In the muon frame, which effect in special relativity best explains this observation?

- W) Length contraction
- X) Loss of simultaneity
- Y) Time dilation
- Z) Rear clock ahead

ANSWER: W) Length contraction

## **BONUS**

7) PHYSICS *Short Answer* Aprameya is playing with a large square pillow with dimensions 2 meters by 2 meters and height 0.5 meters. He sits on the pillow and finds that it only depresses by one centimeter. Given that Aprameya has a mass of 60 kilograms, find the Young's Modulus of the pillow, in Pascals, to one significant figure.

ANSWER: 7000

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## **TOSS UP**

8) MATH *Short Answer* Two primes add up to 31. What is their product?

ANSWER: 58

## **BONUS**

8) MATH *Short Answer* Amy picks two integers between 1 and 6, inclusive, at random. What is the probability that one number divides the other?

ANSWER: 11/18

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## TOSS UP

9) CHEMISTRY *Multiple Choice* When chlorine gas is bubbled through hot, concentrated aqueous alkali, which of the following chlorine-containing anions is the major product?

- W) Hypochlorite
- X) Chlorite
- Y) Chlorate
- Z) Perchlorate

ANSWER: Y) Chlorate

## BONUS

9) CHEMISTRY *Multiple Choice* Which best compares the Maxwell-Boltzmann distributions for helium and xenon at 500 K?

- W) Helium's distribution is more narrow and further to the left than xenon's distribution.
- X) Helium's distribution is more narrow and further to the right than xenon's distribution.
- Y) Helium's distribution is more wide and further to the left than xenon's distribution.
- Z) Helium's distribution is more wide and further to the right than xenon's distribution.

ANSWER: Z) Helium's distribution is more wide and further to the right than xenon's distribution.

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## TOSS UP

10) BIOLOGY *Multiple Choice* A key step of the urea cycle involves the arginase-catalyzed breakdown of one molecule of arginine into one molecule of ornithine, which is structurally similar to lysine, and how many molecules of urea per molecule of arginine?

- W) 0
- X) 1/2
- Y) 1
- Z) 3/2

ANSWER: Y) 1

## BONUS

10) BIOLOGY *Short Answer* To diagnose tapeworm infections in pets, veterinarians can look for the presence of certain broken-off tapeworm segments in feces. What is the name for these segments, which are posterior to the scolex and reproductive in nature?

ANSWER: Proglottids

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## TOSS UP

11) EARTH AND SPACE *Short Answer* Order the following three evolutionary stages of a 1 solar mass star in chronological order:

- 1) Horizontal branch
- 2) Helium flash
- 3) Asymptotic giant branch

ANSWER: 2, 1, 3

## BONUS

11) EARTH AND SPACE *Short Answer* Identify all of the following statements that are true, comparing a O-type star and an A-type star:

- 1) The O-type star would have more neutral hydrogen lines
- 2) The O-type star would have more ionized spectral lines
- 3) The O-type star would have a higher peak wavelength in its continuous emission

ANSWER: 2 only

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## TOSS UP

12) PHYSICS *Multiple Choice* Which one of the following quantities concerning electric and magnetic fields must always be 0?

- W) The curl of a magnetic field
- X) The curl of an electric field
- Y) The divergence of a magnetic field
- Z) The divergence of an electric field

ANSWER: Y) The divergence of a magnetic field

## BONUS

12) PHYSICS *Multiple Choice* Krutharth connects a battery to a capacitor, causing it to build up charge. He then slides a dielectric halfway between the plates of the capacitor. Which of the following best describes the result?

- W) The dielectric is sucked into the capacitor
- X) The dielectric is expelled from the capacitor
- Y) The dielectric stays in place
- Z) Depends on the direction of the battery

ANSWER: X) The dielectric is expelled from the capacitor

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## TOSS UP

13) MATH *Short Answer* What is the tangent of the arccosine of  $3/7$ ?

ANSWER:  $\frac{2\sqrt{10}}{3}$

## BONUS

13) MATH *Short Answer* A sequence has first term 2, and every subsequent term is found by multiplying the previous term by 2 and subtracting 1. What is the last digit of the hundredth term?

ANSWER: 9

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## TOSS UP

14) CHEMISTRY *Short Answer* By name or number, order the following 3 carboxylic [READ: *car-box-ILL-ick*] acid derivatives by increasing electrophilicity [READ: *electro-fill-IH-si-tee*]:

- 1) Anhydride
- 2) Acid chloride
- 3) Ester

ANSWER: 3, 1, 2

## BONUS

14) CHEMISTRY *Multiple Choice*  $\text{Fe}^{2+}$  ions are oxidized by potassium permanganate in acid under standard conditions, producing  $\text{Mn}^{2+}$  ions and  $\text{Fe}^{3+}$  ions. Which change will cause the greatest increase in cell potential for this reaction?

- W) Doubling the concentration of  $\text{Fe}^{2+}$
- X) Tripling the concentration of  $\text{MnO}_4^-$
- Y) Halving the concentration of  $\text{Mn}^{2+}$
- Z) Increasing the pH by one unit.

ANSWER: W) Doubling the concentration of  $\text{Fe}^{2+}$

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## TOSS UP

15) BIOLOGY *Multiple Choice* Which of the following antigens will not be recognized by a Toll-like receptor?

- W) Flagellin
- X) Lipopolysaccharide [*Lie-po-poly-sack-er-ide*]
- Y) Rhesus Factor
- Z) Double-stranded RNA

ANSWER: Y) Rhesus Factor

## BONUS

15) BIOLOGY *Multiple Choice* According to the island equilibrium model, which of the following islands would be expected to have the highest rate of local extinction at equilibrium?

- W) A small island close to the mainland
- X) A large island close to the mainland
- Y) A small island far from the mainland
- Z) A large island far from the mainland

ANSWER: W) A small island close to the mainland

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## TOSS UP

16) EARTH AND SPACE *Short Answer* Order the following three substances in terms of increasing viscosity:

- 1) Lava from a shield volcano
- 2) Lava from a stratovolcano
- 3) Lava from a cinder cone

ANSWER: 1, 3, 2

## BONUS

16) EARTH AND SPACE *Short Answer* Identify all of the following three features that are associated with convergent plate boundaries:

- 1) Accretionary wedges
- 2) Fore-arc basins
- 3) Back-arc basins

ANSWER: All

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## TOSS UP

17) PHYSICS *Multiple Choice* A plasmon is a type of collective excitation in plasmas that does not obey the Pauli Exclusion principle. What set of statistics do plasmons satisfy?

- W) Bose-Einstein
- X) Fermi-Dirac
- Y) Maxwell-Boltzmann
- Z) Gaussian

ANSWER: W) Bose-Einstein

## BONUS

17) PHYSICS *Short Answer* Aldric is feeling silly and stacks 100 glass sheets on top of each other, with the  $n$ th pane from the top having an index of refraction of  $n$ . He shines a beam of light at a 60 degree angle from the horizontal at the top pane. To two significant figures and in radians, what angle does the light beam make with the vertical as it passes through the 100th glass sheet?

ANSWER: 0.0050

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## TOSS UP

18) MATH *Short Answer* A regular polygon has an internal angle of 177 degrees. How many side lengths does it have?

ANSWER: 120

## BONUS

18) MATH *Short Answer* What is the ratio between the number of factors of 50 factorial and the number of factors of 51 factorial?

ANSWER: 23/32

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## **TOSS UP**

19) CHEMISTRY *Multiple Choice* Which of the following salts will have the lowest solubility in 0.1 M aqueous ammonia?

- W) Silver fluoride
- X) Silver chloride
- Y) Silver bromide
- Z) Silver iodide

ANSWER: Z) Silver iodide

## **BONUS**

19) CHEMISTRY *Multiple Choice* According to molecular orbital theory, which best describes the magnetic properties of S<sub>2</sub>?

- W) Ferromagnetic
- X) Antiferromagnetic
- Y) Diamagnetic
- Z) Paramagnetic

ANSWER: Z) Paramagnetic

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## **TOSS UP**

20) BIOLOGY *Short Answer* Which oxygen-carrying protein found in the root nodules of legumes helps provide an anaerobic environment for nitrogen fixation?

ANSWER: Leghemoglobin

## **BONUS**

20) BIOLOGY *Multiple Choice* Widely distributed and abundant in lake beds and marine environments, gastrotrichs [*gas-tro-tricks*] are best classified as which of the following based on body cavity?

- W) Coelomate [*see-lom-ate*]
- X) Psuedocoelomate [*soo-do-see-lom-ate*]
- Y) Acoelomate [*A-see-lom-ate*]
- Z) None of the Above

ANSWER: Y) Acoelomate

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## TOSS UP

21) EARTH AND SPACE *Multiple Choice* Aprameya wants to observe the accretion disk of a neutron star. Which of the following telescopes would be the best choice for Aprameya to use?

- W) Spitzer
- X) Compton
- Y) James Webb
- Z) Chandra

ANSWER: Z) Chandra

## BONUS

21) EARTH AND SPACE *Short Answer* Identify all of the following Lagrange points in the Earth-Sun system where, if an object is placed there, it would remain in stable equilibrium:

- 1) L1
- 2) L2
- 3) L3

ANSWER: None

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## TOSS UP

22) PHYSICS *Short Answer* Sound waves may be modelled as the compression and expansion of air molecules. For frequencies in the human hearing range, what characteristic best describes these processes in sound waves?

- W) Isobaric
- X) Isochoric
- Y) Isothermal
- Z) Adiabatic

ANSWER: Z) Adiabatic

## BONUS

22) PHYSICS *Short Answer* Which of the following are equivalent to the Second Law of Thermodynamics?

- 1) A thermodynamic process cannot result in the transfer of heat from a colder object to a hotter one
- 2) A heat engine cannot operate with 100% efficiency
- 3) The entropy of a thermodynamic system can never decrease

ANSWER: 2 only

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## TOSS UP

23) MATH *Multiple Choice* There is a constant fixed probability that a shopper enters a clothing store at any given second. Which of the following probability distributions best represents the number of shoppers the clothing store gets over an hour?

- W) Poisson Distribution
- X) Geometric Distribution
- Y) Hypergeometric Distribution
- Z) Binomial Distribution

ANSWER: W) Poisson Distribution

## BONUS

23) MATH *Short Answer* How many factors does the integer 40320 have?

ANSWER: 96

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## TOSS UP

24) CHEMISTRY *Multiple Choice* Which of the following best describes the relationship between cis-2-butene and trans-2-butene?

- W) Enantiomers [*enn-ANT-ee-oh-mers*]
- X) Rotamers [*ROWT-ah-mers*]
- Y) Conformers [*CONN-for-mers*]
- Z) Diastereomers [*die-ah-STAIR-ee-oh-mers*]

ANSWER: Z) Diastereomers

## BONUS

24) CHEMISTRY *Multiple Choice* Which volatile nickel-containing compound is involved in the Mond process for producing high-purity nickel?

- W) Gaseous nickel
- X) Nickel tetracarbonyl
- Y) Nickel (II) sulfide [READ: *nickel two sulfide*]
- Z) Nickel (II) chloride [READ: *nickel two chloride*]

ANSWER: X) Nickel tetracarbonyl

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## TOSS UP

25) BIOLOGY *Multiple Choice* Which of the following groups of protists most commonly possesses two flagella?

- W) Radiolarians
- X) Euglena
- Y) Diplomonads
- Z) Oomycetes

ANSWER: X) Euglena

## BONUS

25) BIOLOGY *Short Answer* Aprameya eats 1000 Calories of Thanksgiving dinner. The next day, Aprameya loses 350 Calories of his dinner as waste, and burns 400 Calories via metabolism. The rest of his dinner is assimilated into his body. What is Aprameya's production efficiency of his Thanksgiving dinner?

ANSWER: 1/4

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